Gibbons

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Journal of the New England Water Works Association

ISSUED QUARTERLY

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OF THE
New England Water Works Association
1949-1950

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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 900 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than sixteen years nor more than twenty-five years of age, a student or connected with water supply work.

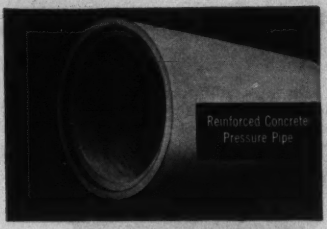
An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

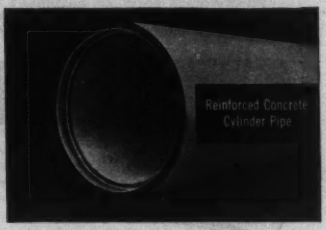
A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation. The initiation fees and annual dues are as follows:

	Initiation Fee		*Annual Dues*
Members	$ 5.00	Members	$ 5.00
Juniors	1.00	Juniors	2.00
Associates	10.00	Associates	25.00
Corporate Members	10.00	Corporate Members	25.00

This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one the annual convention, held in September on such date as the Executive Committee may designate.

let LOCK JOINT solve your water supply problems





Lock Joint's four designs of reinforced concrete pressure pipe answer any problem in the field of large-diameter water supply conduits.

All of these designs may be equipped with Lock Joint's flexible, self-centering Rubber and Steel Joint, which simplifies installation and reduces the initial cost of laying the line.

Lock Joint Reinforced Concrete Pressure Pipe is made in all standard diameters from 16" up, and will withstand any pressure common to American water works practice.

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Your inquiry at any of the Company's offices will receive a prompt reply.

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Reinforced Concrete
PRESSURE PIPE

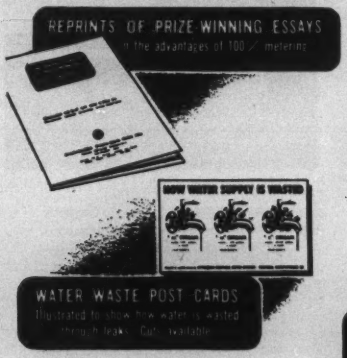
SCOPE OF SERVICES—Lock Joint Pipe Company specializes in the manufacture and installation of Reinforced Concrete Pressure Pipe for Water Supply and Distribution Mains in a wide range of diameters as well as Concrete Pipe of all types for Sanitary Sewers, Storm Drains, Culverts and Subaqueous Lines.

ARE YOU LOSING AN ADEQUATE WATER SUPPLY THROUGH NEEDLESS WASTE?

TO CONSERVE WATER . . . *METER ALL SERVICES*

The nationwide water shortage has been widely publicized. Never before are so many people water-conscious. If your system is not 100 per cent metered you know that much water is being wasted. Now is the time to advocate metering to your consumers and municipal officials. You'll do yourself and the community a service. To help you "sell" this idea we have prepared a complete portfolio of factual data on how a community is benefited by metering all services. Write for it today — no obligation involved.

WRITE FOR THIS PORTFOLIO OF EDUCATIONAL AIDS


REPRINTS OF PRIZE WINNING ESSAYS
on the advantages of 100% metering
NEWS
NEWS
PUBLICITY STORIES
on meters and the advantages of meter ing for release to local newspapers
HOW WATER SUPPLY IS WASTED
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CASE HISTORIES
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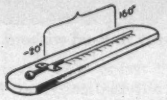
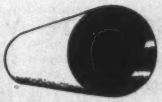
5 OUTSTANDING ADVANTAGES

of Barrett* protective coatings for the Water Industries

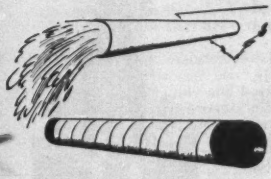


1. **They are unaffected by Wide Temperature Changes** Barrett* Waterworks Enamels neither flow nor sag in temperatures as high as 160°F. Nor do they crack in temperatures as low as 20° below zero.

2. **They are Flexible and Ductile** They possess sufficient elasticity to withstand "breathing" of the pipe as pressures fluctuate, and out-of-round deflection when the pipe is being installed or by the weight of the backfill when the pipe is out of service.



3. **They prevent Tuberculation** When used to line the inside of a pipe, Barrett Waterworks Enamels prevent tuberculation, thus enabling the pipe to maintain its original capacity.



4. **They increase the Coefficient of Flow** After lining with Barrett Waterworks Enamels, Hazen-Williams "C" averages 150. Initial power installation is less expensive, and owing to the prevention of tuberculation, the cost of power does not increase after years of service.

5. **They assure Firm Bond** Barrett Waterworks Enamels assure a firmer bond at the interfaces of steel, primer, and enamel.

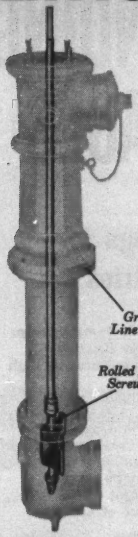
BARRETT WATERWORKS ENAMELS are manufactured specifically to meet the requirements of the water industries. Long and extensive service in the field has proved their worth. The Barrett organization will be glad to advise on materials and on application procedure, and to consult with you on any pipe-coating problem.

Barrett®

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 Rector Street, New York 6, N. Y.

*Reg. U. S. Pat. Off.

SERVICE . . . *with a monkey wrench!*



To inspect or service a Ludlow Slide Gate Hydrant you'll need a wrench — that's all. Just take off the top of the hydrant and lift out the stem, *without unscrewing anything below ground.* The entire mechanism, including the gate, bronze wedge nut and drip assembly is attached to the stem.

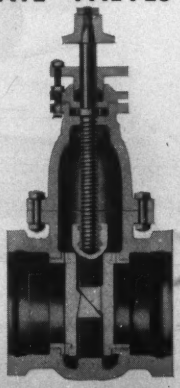
LUDLOW FIRE HYDRANTS

Shown here is the distinctive Ludlow List No. 90, now serving in thousands of cities and towns. It employs the famous Ludlow Slide Gate principle, and (in addition to easy servicing) offers the following advantages:

- *Quick Water* with least possible shock and pressure loss. Proper shut-off without water hammer.
- *Proper Drainage*, automatically, at lowest point when closed.
- *No Flooding.* Wedge-locked when closed. Accidental breaking will not cause flood. Hydrant head breaks at ground line — is easily replaced without excavation.

LUDLOW AWWA DOUBLE DISC GATE VALVES

The parallel seated, double wedge type slide gate valve, developed and perfected by Ludlow, provides a number of essential benefits.



- *Smooth, Positive Operation.* Gates positioned directly opposite ports before wedging, and entirely unwedged before being raised.
- *Positive Closure.* Even after years of service in the open position; flexible-action gates self-adjusting to seats.
- *Simplicity!* Only 2 parts in the wedging mechanism! These are extra heavy with ample reserve strength and wear resistance for years of constant service.

Made in sizes from 2″ to 72″, N.R.S. and O.S.&Y. with all types of connections. 93-S

TRADE LUDLOW MARK

The LUDLOW VALVE MFG·CO·INC·TROY·N·Y·

SINCE 1866

A Dresser-coupled steel line delivers water cheaper...

The cheapest way to deliver water to the place where it turns into revenue is with a Dresser-coupled steel line—the line that

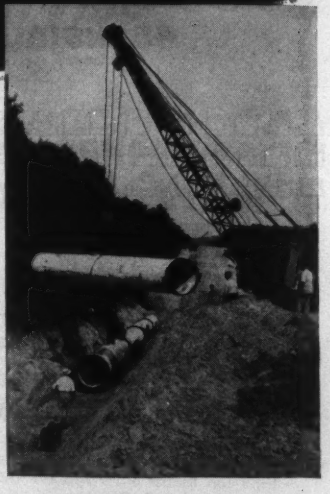
- **Cuts installation costs**
- **Cuts leakage losses**
- **Cuts maintenance costs**

Strong, shatterproof, yet lighter in weight, steel pipe swings into place easily. Each section goes as far as several sections of more cumbersome alternate pipe. You have fewer joints, and those more easily and quickly made with Dresser Couplings. Your line is in service sooner . . . you save costly man-hours.

The flexibility of Dresser Couplings cushions every joint and harmlessly absorbs vibration and other stresses that cause rigid lines to leak. You get a permanently tight line that delivers all the water you put into it.

You save on maintenance because the flexible-tight Dresser line "lives in the ground" comfortably and because modern glass-smooth linings assure high-sustained carrying capacity, life-long service.

See your Dresser Sales Engineer, or write today for literature.



In Springfield, Mass., as many as 40 long lengths of pipe were laid and joined in an eight-hour day, using a two-man joining crew.

Be sure you get the best line at the best price. Put steel pipe and Dresser Couplings in your specifications.

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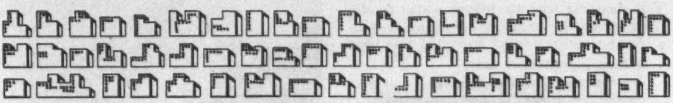
257 FIELD REPRESENTATIVES

48 INSTALLATION INSTRUCTORS



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5 MANUFACTURING LOCATIONS

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Its facilities include more than 250 field representatives with headquarters in 58 cities. It also comprises a staff of competent installation instructors who explain recommended installation practices to pipe-laying crews. This Johns-Manville service is an important factor in helping to assure the installation economies as well as the long-term *overall* economies that go with Transite Pressure Pipe.

Behind this field organization are the modern production methods which assure the high quality of the finished product. These begin with careful selection of raw materials and are continued through the special processing operations to the final tests which each individual length of pipe must undergo before shipment is made. Five conveniently located plants now service Transite Pipe users from coast to coast.

And back of all this is engineering —and research. For without them, the plus values that have been built into Transite Pipe would not have been possible. Today, in the new J-M Research Center, the engineer and the technician continue to find new answers to old problems. Their work is an indispensable part of the complete Transite Pipe service which Johns-Manville offers the waterworks industry. For further information, write Johns-Manville, Box 290, New York 16, N. Y.

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TRANSITE ASBESTOS—CEMENT PRESSURE PIPE

FOR BETTER WATER SERVICE

just don't come too big for Koppers!

▼ Look at the 120-foot section of 66-inch steel pipe pictured above. It's only a *small fraction* of the new 10,000-foot intake pipe line of the Saginaw-Midland Water Project, Saginaw, Michigan. This entire pipe line, inside and out, has been protected against corrosion with Koppers Bitumastic® 70-B Enamel.

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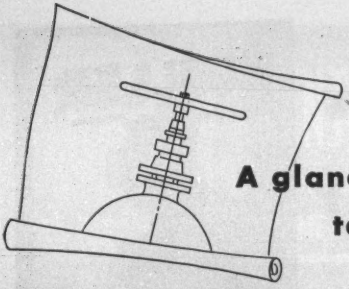
Why not submit your corrosion problems to our Contract Department? Write us today.

KOPPERS **PROTECTIVE COATINGS** ®T. M. Reg. U. S. Pat. Off.

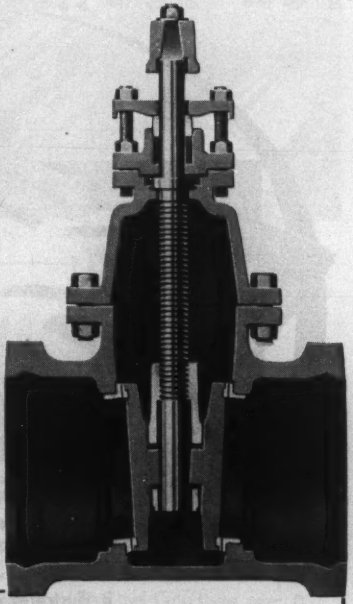
KOPPERS COMPANY, INC., Dept. 315T, Pittsburgh 19, Pa.



A glance at the blueprint tells the story

One look at the design of R. D. Wood Gate Valves and you know they will deliver superior service—they are so simple, rugged and foolproof. An important feature is that there are only three working parts—the spreader and two discs. No small wedges or delicate devices to fail in an emergency. No pockets to fill up with sediment or scale. The valves are fully bronze mounted, all surfaces making a tight seal. They close completely and open fully. In closing, the gates descend opposite the seats before the spreading action is applied. In opening, they move free of the seats before rising into the bonnet and permit unobstructed flow.

Made of thoroughly seasoned castings, rigidly inspected, and tested to 300 pounds hydrostatic pressure, R. D. Wood Gate Valves conform to A.W.W.A. specifications. They are a safety-plus factor for every modern community. Write for complete information today.

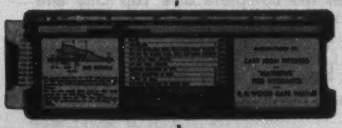


R. D. WOOD COMPANY

Public Ledger Building

Independence Square, Philadelphia 5, Pa.

Manufacturers of Mathews Hydrants and "Sand-Spun" Pipe (centrifugally cast in sand molds)



R. D. Wood Company
Public Ledger Building, Phila. 5, Pa.

Please send me a Cast Iron Pipe Calculator absolutely free.

FREE!

Send for this Cast Iron Pipe Calculator. Determines, at a glance, class, weight and dimensions of bell and spigot pipe.

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This new MUELLER Blue Top Catalog is meant to provide engineers and water works men with a simple, accurate means of selecting their water works brass goods requirements. It illustrates the complete Blue Top Line and gives full dimensional data on each item. You'll find it invaluable for constant reference, so if you haven't a copy handy right now, don't delay — write for one today.

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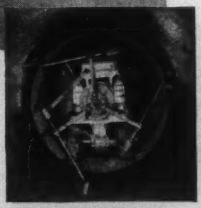

CENTRILINE CORPORATION

A subsidiary of Raymond Concrete Pile Co.

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NEW YORK 6, N. Y.

Branch Offices in all Principal Cities in the United States and Latin America.

In Cincinnati's program to recondition its water mains for greater efficiency and economy, Centriline has recently completed its fifth contract since 1940.

A total of more than 68,000 feet of cast iron pipe has been cleaned and uniformly lined with dense cement mortar in this city. Pipe sizes were from 24" to 48". On the last job, the average speed of lining was better than 1,000 feet per day—resulting in minimum interruption in water distribution.

Cincinnati has found that Centrilining pays. It will establish and maintain a high coefficient, reduce pumping cost, stop all leakage and terminate deterioration. Consult Centriline's experienced hydraulic engineers. A 28-page illustrated bulletin is also available on request.

CEMENT MORTAR LININGS FOR WATER MAINS CENTRIFUGALLY APPLIED in strict conformity with A. W. W. A. Specifications.

Badger Meters solve city's water supply and financial problems

This city's demands for water were expanding. Two wells and the pumping facilities appeared inadequate. No overhead reservoir was available. Financing a third well and pumps was impractical. Water wastage (before installing Badger Meters) seemed excessive. The city decided to try metering as a means of reducing waste. Result: after metering, 24-hour flow was reduced over 55%. No new well needed. The water supply problem was solved . . . so was the financing problem! You, too, will find "It pays to BUY BADGER".

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Milwaukee 10, Wisconsin

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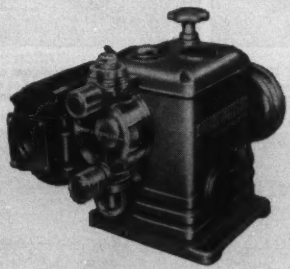
New York City • Philadelphia • Worcester, Mass. • Savannah, Ga. • Cincinnati • Chicago Kansas City, Mo. • Waco, Texas Salt Lake City, Utah • Portland, Ore. • Seattle, Wash. • Los Angeles

You will find a Badger Meter size and type for every waterworks service. Shown here are Model SC-IOT (for warm climates), and Model A-IOT (for cold climates) . . . sizes ⅝" to 1¼" . . . other models in sizes up to 12". Write for complete information and prices.

BADGER Water METERS

ACCURACY · LOW-COST MAINTENANCE · DURABILITY · SENSITIVENESS

Does YOUR Pumped Water Supply Need Treating?



%Proportioneers% New Improved Heavy Duty Chem-O-Feeder. Positive displacement diaphragm type pump with feeding rate instantly adjustable while pump is operating. Has plastic "See-Thru" reagent head and many exclusive features. Capacity 0-8 gals./hr. against pressures 0-100 lbs./sq. in. Also available in duplex and triplex models.

Here's the simple water treating system that's worth looking into . . . whether you pump a few hundred or a million gallons per day. %Proportioneers% Heavy Duty Chem-O-Feeder treats your water supply automatically, dependably. You can feed almost any water treating chemical — hypochlorite, polyphosphates, coagulants, pH control chemicals, or slurries. No more attention is required than filling the chemical reagent tank periodically — the Chem-O-Feeder runs in unison with the water pump and provides the exact chemical feeding you need.

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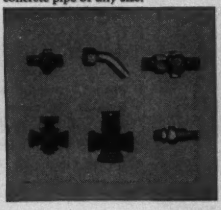
Fire Hydrants, of the compression type featuring Protectop collision protection, frost-proof tapered barrel, and positive action drain.

Gate Valves, for low, medium or high pressure service. Manual, hydraulic cylinder, or motor operation.

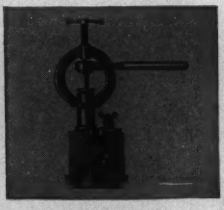
Tapping Sleeves and Valves, for making branch connections (sizes 2" thru 42") under pressure to cast iron, steel, asbestos-cement or reinforced concrete pipe of any size.

Inserting Valves, for installation under pressure in cast iron, steel or asbestos-cement pipe. Sizes 4" thru 48".

Pipe Cutting Machines. With the SMITH machine a true "lathe" cut can be made in cast iron, steel or asbestos-cement pipe in a minimum time.



Water Service Brass Goods: corporation—curb cocks, couplings and other fittings for copper tube, lead and iron pipe services.



Corporation Tapping Machines. With the SMITH Tapping Machines corporation cocks can be installed under pressure. The machine is compact and easy to operate.

*** Water works material of proven quality**

THE A. P. SMITH MFG. CO.

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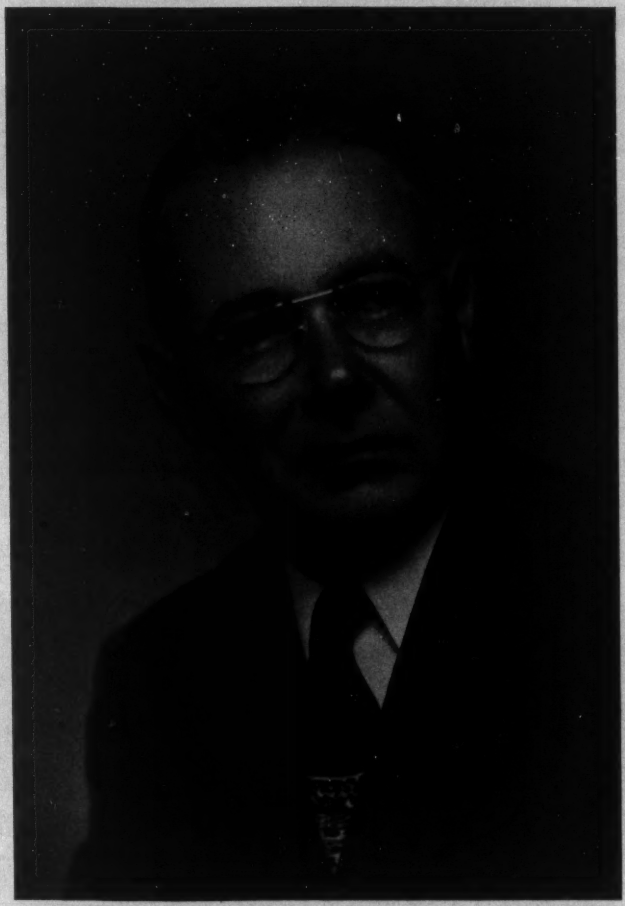

SIDNEY S. ANTHONY

President of the New England Water Works Association, 1949-50.

New England Water Works Association
ORGANIZED 1882

VOL. LXIV MARCH, 1950 NO. 1

This Association, as a body, is not responsible for the statements or opinions of any of its members

PROGRESS REPORT ON CHLORINE DIOXIDE

BY R. N. ASTON*

[*Read at Chemists' Round Table, March 17, 1949.*]

COMPARED to other methods of water treatment and their histories, the use of chlorine dioxide (ClO_2) in the treatment of water is still in its infancy. It is, however, well established and showing continuous rapid growth. It is now in use in well over 100 municipalities in the United States and a number in Canada. We appreciate the opportunity to return to Boston and give a progress report on the latest developments in the use of the process.

From the initial use for taste and odor control in phenolic waters, the process has grown to include use for the control of tastes and odors due to algae and decayed vegetation, and in numerous other taste and odor problems. As will be shown further and has also been discussed here previously, chlorine dioxide has definite bactericidal power, comparable to chlorine (1). It aids in the maintenance of an active chlorine residual in the distribution system, making this possible where in many cases this had been previously unattainable. It also can be used for the removal of iron and manganese and in some instances reduction of color.

Although the details have been given in other papers, the writer would like to mention briefly again the method used to apply chlorine dioxide to the average water supply (2). Many of those responsible for water treatment do not realize how simple and inexpensive it is to try chlorine dioxide on their own supply. We all realize that chlorine dioxide is not a cure-all for all water problems. The only way its usefulness in any particular problem can be determined is to try it on a plant scale on the problem at hand.

The equipment necessary to do this consists of a chlorine-dioxide solution generator, one or possibly two proportioning pumps and one

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or two crocks or tanks to hold the chlorite solution. Both the generator and the pump will be loaned to any plant for a reasonable trial period. The only material necessary to purchase, besides the crock, is the technical sodium chlorite. In this way it is possible without any capital investment to determine the effectiveness of chlorine dioxide in solving the particular problem, whether taste and odor, bacteriological or maintenance of the residual. Technical assistance will be furnished if necessary to aid any plant in trying out the process. The purchase of the equipment after a satisfactory trial period costs about $1,000 or less—still a negligible investment for any plant to achieve a satisfactory result.

As suggested above, we generate the chlorine dioxide by pumping a solution of sodium chlorite by means of a proportioning pump into a glass reaction chamber. This generator also receives the complete discharge of the usual chlorinator, interfering in no way with the operation of the chlorinator. In the generator the chlorine and chlorite solutions react, to give an aqueous solution of chlorine dioxide. This is then fed to the point of application, which may, as the conditions warrant, be before or after filtration.

Let us now consider a specific example, to see how chlorine dioxide may be applied and the advantages that may accrue. The officials of a large city in Texas were having considerable difficulty with taste and odor in the finished water and a number of treatments tried had not produced results up to the high standards they had set for themselves (3). Therefore, last summer they obtained the necessary equipment and chemicals for a trial of chlorine dioxide. In the case of this city it was somewhat of a question whether it was decomposed vegetation, weeds or algae that produced the taste and odor. Plankton counts run in past years had never shown the presence of any organisms in quantities to produce taste and odor.

It might be well to state here that, as you probably know, there are many answers to the fundamental chemistry of water which are as yet unknown. We do not know the mechanism of many reactions in water chemistry nor even specifically the materials themselves which may cause the many tastes and odors we have to combat. However, it is usually possible with the tools at hand to produce satisfactory results.

In the case of the city cited, satisfactory results were obtained, although the causes of the tastes and odors in the water are still somewhat of a question. Chlorine dioxide was applied to the filtered water in this plant. Varying dosages were used, the first of which—about 3 lb of chlorite per mil gal—produced a satisfactory water at the plant but the quality deteriorated in the system, causing many complaints. In the face of these complaints, the water-department officials persisted in their efforts to solve the problem. Finally, a dosage of 10 lb per mil gal of sodium chlorite produced a satisfactory water for the consumer. The final treatment process consisted of break-point chlorination, applied to the water at the lake as had been the practice for some time. This was followed at the plant by alum treatment and filtration, followed by chlorine dioxide. It was possible to maintain the quality, even though control of the break-point chlorination process was lost at times, due to circumstances beyond the control of the operator. The results of the process in this city can be summarized as follows:

1. During the final trial period of this process, a water with satisfactory taste and odor was produced at all times at the plant and carried throughout the system. It was felt that the quality of the water, as far as taste and odor were concerned, was equal or superior to that normally produced by the carbon treatment, at the plant and throughout the distribution system.
2. An active chlorine residual was maintained to the end of the distribution system, thus aiding in the maintenance of the bacteriological quality and safety of the water to the consumer.
3. A definite trend was seen towards improvement of the bacteriological quality of the water as it left the plant, as indicated by a drop in the number of presumptives found in the finished water. Longer periods of operation should definitely prove this trend.
4. A very definite reduction in the chemical costs of operation was noted. Based upon actual operating figures, this cost showed a reduction of $3.50 per mil gal or $52.95 per day, with an estimated saving ranging nearer to $8.15 per mil gal or $122.25 per day. This saving is accomplished by the elim-

ination of carbon and consequently by a reduction in the alum necessary for operations.

5. It is expected that in continuous operation a reduction in the amount of wash water necessary will be shown.
6. It is also expected that in continuous operation longer filter runs will be obtained when the chlorine-dioxide process is employed.
7. Operations indicated that the process can be easily employed with the normal control methods available at the plant.

Let us look, therefore, in detail for a moment at some of the points which were brought out in this application and others which may apply to your water plant.

First, a taste and odor problem was solved, although we still do not know in detail the true cause of the problem. The condition may have been due to algae, vegetation or some other source, but the results obtained were superior to methods of treatment previously employed or tried.

Secondly, it was possible with the chlorine-dioxide process to maintain a residual throughout the distribution system. We have seen this occur in a number of installations (4). A point might be explained here in regard to this residual. Analysis and study of various distribution systems have shown that the residual found at the end of the system is chlorine dioxide and not chloramine or free chlorine. Moreover, work which has been completed and will be cited later has shown that a chlorine-dioxide residual is an effective bactericide.

Thirdly, as was noted elsewhere and was cited in a paper given before your Association in September, 1947, concerning the operations at Chicopee Falls, Mass., definite improvement was shown in the bacteriological quality of the water treated by chlorine dioxide (1). In this instance it was noted that a definite drop in presumptives took place in the finished water at the plant.

In connection with bacteriological considerations, studies on the effectiveness of chlorine dioxide in comparison to chlorine, beyond those already published, have been completed by Dr. G. M. Ridenour of the University of Michigan and will be published in the near future (8).

To consider problems of taste and odor briefly before closing, many articles have been published citing examples of different types of taste and odor problems that have been solved (6, 7). One type that has been most difficult to handle is that due to algae. We recently carried out a study where, in eight different plants and areas, plankton counts were run on the raw water once or twice a week through the critical period. A number of the plants had severe algae problems. Many types of algae were responsible for the taste and odor, such as Synedra as high as 1,260 standard areal units, Aphanizomenon over 15,000 standard areal units, Asterionella, Melosira, etc. While in many cases dosages of chlorite were higher than normally required to combat taste and odors due to industrial wastes, chlorine dioxide usually costs no more than other conventional methods of treatment and produces other advantages, as previously cited, along with taste and odor control.

Another recent development in the application of chlorine dioxide to water supplies has been an improvement in the determination of chlorine-dioxide residuals in the treated water. It is now possible by means of an amperometric titration to determine in treated water, with accuracy to about 0.01 ppm, various forms of chlorine, such as free chlorine, chlorine dioxide, chloramine and chlorite. The details of this method of analysis have been publised under the title "Determination of Chlorine Dioxide and Other Active Chlorine Compounds in Water" by Haller and Listek in *Analytical Chemistry*, Vol. 20, July, 1948. This method of analysis, while not recommended for routine control operation in a water plant, is available and suitable for use in research and studies in plants where time and manpower make it feasible. Work is also under way in our laboratory with promising results on another method of determining chlorine dioxide. This method will be a simple adaptation of the orthotolidine-arsenite test. In all probability this test will be one which could be employed in routine control in the average water-works plant and will make it possible to determine chlorine dioxide as distinguished from free chlorine. It might be well to mention here that in the normal OT or OTA test chlorine dioxide is indistinguishable from free chlorine. About one-fifth of the available chlorine present as chlorine dioxide will show in the flash test or the OTA test as free chlorine. This does not nor-

mally constitute any particular problem, as we have already shown that a residual of chlorine dioxide on an OTA or OT basis is as effective a bactericide as chlorine.

Another paper of importance recently published on chlorine dioxide is entitled "Chemical Properties of Chlorine Dioxide in Water Treatment", by Ingols and Ridenour, in the *Journal of the American Water Works Association* for November, 1948. This paper is an important contribution to understanding further the reactions of chlorine dioxide in water treatment. The data in this paper show, for example, that chlorine dioxide is less reactive than chlorine with many organic substances in low concentrations. This explains the ability to apply chlorine dioxide in many cases to raw water without needing excessive amounts of chlorine dioxide to produce the desired results. It also brings out the fact that chlorine dioxide will not react with ammonia in water, thus making it possible to have a chlorine-dioxide residual in water without the necessity of going through a break-point with chlorine or a similar situation with chlorine dioxide itself. Incidentally, this conclusion has been confirmed in a paper published in the *Journal of the Institution of Water Engineers*, Vol. 2, No. 1, 1948, by A. T. Palin, entitled "Chlorine Dioxide in Water Treatment". This is an English publication which, as I have indicated, confirms many of the things that have been found in this country with respect to chlorine dioxide and its reactions.

Thus we find that considerable progress has been made in the understanding and application of chlorine dioxide to numerous water problems.

In conclusion, the following points should be considered when contemplating the use of chlorine dioxide:

1. Ability to handle taste and odor problems due to many causes, such as phenolic wastes, other industrial wastes, sewage, algae and decomposed vegetation.
2. An aid in maintaining an active chlorine residual in the distribution system and thus maintaining the quality of the water all the way to the consumer.
3. Bactericidal properties equal to or better than chlorine against numerous organisms found in water, the ClO_2 thus aiding

in maintaining and improving bactericidal control and quality in the water plant and system.

4. A process which is easy to operate and does not require special laboratory control.
5. A treatment which is usually equal to or cheaper than other methods in use for taste and odor control.

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SOME PROBLEMS IN WATER-WORKS CONSTRUCTION

BY RALPH H. WHITE*

[*Read March 17, 1949.*]

THE problem of water-works construction is an old problem, a simple one, a human one. It is part of the recital of the struggle of all human beings to raise their standards of living through the ages. In using science to aid them, water works have helped change their habits of living.

For the purposes of convenience, let us anchor this story to ancient days. Then, men did the work of the world largely by hand and worked long hours at manual labor. When the theaters of Ancient Rome were built, the only labor-saving device in use was the inclined plane, which lessened the amount of muscle required to raise a pre-cut stone to its marked position.

Next, man learned to harness the wind. He captured it in sails. The galley slaves who had rowed the boats were replaced by progress, by man's search for a higher standard of living.

The only *basic invention* man has ever made is the wheel. That was discovered by the Chinese and brought back to Europe by pioneer tradesmen and explorers, who had ventured into the Far East. The idea of the wheel is a continuous footstep rolled up, with a center or hub around which the wheel may revolve. All other inventions we enjoy today are the results of finding some force of nature already in existence.

Having discovered the wheel, man then harnessed the power of the wind to it, to save on physical labor and to pump his water.

Shortly afterwards, a scientist watched a teakettle boil. He said, "There is power in that escaping steam." We learned to burn coal and wood and to harness the power from the steam to modifications of the Chinese wheel. A steam engine was born; a new era was opened; our standard of living was raised, and our physical labor was lessened.

We in America have learned to utilize all forms of power and

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apply them to every known modification of the wheel. We have the highest standards of living. This development of mechanical power has made it possible for us to advance to new levels of comfort, convenience and earning power.

These thoughts I should like to impress upon you—the men who direct water works, the engineers who plan for the future and the manufacturers who design new machines and methods for this old, simple problem:

1. Be an optimist; be ready to try new methods.

2. Give your work quality. Quality is never an accident; it is always the result of high intention, sincere effort, intelligent direction and skillful execution. It represents the wise choice of many alternatives, the gathered experience of many masters of craftsmanship. Quality also marks the search for an ideal after necessity has been satisfied and mere usefulness achieved.

3. Think of the great future of America. Protect and pass on to those who will follow us the endowment which nature has given us.

My problems in water-works construction started in a simple way and the work done 25 years ago was manual, almost to the extent of that of the ancients. In those days, we did all excavation, drilling of rock and backfilling by hand labor. We also used horse power.

After the first World War, trenching machines were brought into use, portable air compressors were put on the market and mechanical power began to take the place of manual labor.

However, one problem solved successfully in our business was a specialty of using manpower. In many towns, we found that the Welfare Board was supporting large numbers of able-bodied men and our proposal for water-main extensions would state that, in the event the contract for the work was awarded to us, we would guarantee to give employment to at least 25 of these idle men, who were being supported by the Town, and we would do all the trenching by hand. Another hand-labor problem we overcame concerned the excavation and construction of gravel-packed wells. This practice of using hand labor was successful, until the Federal government took over with this same manual-labor idea and started Federal-sponsored relief projects.

Construction problems in our business of today deal mainly with some form of the Chinese wheel. All of our work, as far as possible, is done by machinery.

I shall discuss briefly a few specific projects that have problems of general interest, such as a river crossing we made at Scituate, Mass. This crossing was made in the South River, connecting the Marshfield water system to Humarock Beach, a district in Scituate. This submarine water main—550 ft long at high tide—was 10-inch Transite and was the first Transite pipe to be laid in New England. We excavated the river crossing with a stationary hoisting engine, dragging a bucket, to a ditch depth of about 5 ft. Approximately 350 ft of pipe, equal to the distance across low water, was laid at one time.

The method used was to construct a long, continuous wooden skid, upon which the pipe was placed on saddles at proper spacing and held to the skid with straps. This assembled pipe with the skid was dragged across the low-water section of the river by means of the hoisting engine and the remainder of the pipe laid at low tide.

At the time the Metropolitan Water Tunnel was built under the town of Rutland, Mass., the reservoir in Rutland supplying the town of Holden began to lose water, until the 18-inch intake became high and dry. We were asked by the Water Commissioners of Holden to install some kind of emergency pumping supply for them. We therefore constructed a 12-inch siphon out into deeper water, connected it to the supply main and kept this temporary siphon going for two years, supplying the town. At first, when the vacuum was low, the town Water Department would exhaust air from the high point of the siphon with a hand-operated pump; but as the water continued to drop in the reservoir, it was necessary to install a vacuum tank and a power-driven vacuum pump. A manhole was constructed and this equipment installed below ground. The reservoir dropped low enough so that it became necessary to dig up about 40 joints in the 18-inch supply line and recaulk the lead joints, as, of course, this supply line was under vacuum.

We made one railroad crossing several years ago at Orange, Mass., which may be of interest. The engineer in charge specified that a 30-inch corrugated-steel drain pipe be installed under the double tracks and the water main laid inside this steel casing. The corrugated-steel pipe was pushed with two 100-ton jacks, with a man inside the pipe digging out earth ahead of the pipe. We observed that we could al-

ways make good progress with the jacks any time a long freight train was passing over the work.

One of the more difficult problems we have been faced with recently occurred in a town whose water is furnished by 54 driven wells. Under normal pumping conditions, the vacuum pump operated every 18 to 24 hours, but the superintendent noted that the interval was gradually decreasing. This went on until the pump operated every 3 to 4 hours and finally became so bad that the cycle was reduced to 30-45 minutes.

We were called in to locate the trouble, since we were familiar with the field, having installed 21 new wells about ten years before. We immediately looked to the valves on each well for trouble and repacked or inspected them all. No evidence of air leaks was noted, with one or two minor exceptions, and the vacuum pump continued to operate every 45 minutes. It seemed that we were now faced with the task of locating a bad joint or a split pipe, but the question was "How?" The wells covered a large area and were connected to the pumping station by four main suction lines, which joined outside the station. From these four main lines, smaller branches took care of three to four wells each, but there was only one valve in the whole system and that could isolate only the 21 new wells. Closing it had no effect on the air condition, which meant that this part of the well field was not leaking.

We were now reduced to the alternative of either uncovering all of the pipe in the field to locate the leaks, or developing some method of localized testing. The latter course was adopted as being quicker and cheaper and was accomplished as follows:

Each of the four main lines was tapped on the top and a one-inch corporation cock, deeply notched on one side, was inserted with the notch facing away from the station. A small tank, equipped with a water glass, was then connected with copper tubing to the corporation cock. Suction was taken from the top of the tank by a hand diaphragm pump, which drew water from the main until the tank was filled. The pump was then valved off and we had a miniature vacuum tank. Air from the leak would come up the suction main on the top of the pipe and would enter the notched corporation cock and thence

rise into the small tank, where we could observe the rate of entry by means of the water glass. This method soon showed us that only very slight amounts of air were entering the station through three of these mains, while the fourth emptied our small vacuum tank in two or three minutes. By successive taps on this main, we were able to locate two branches that showed air and we subsequently uncovered two split pipes.

CHICOPEE VALLEY AQUEDUCT

BY STANLEY M. DORE*

[*Read May 19, 1949.*]

THE Chicopee Valley Aqueduct is a cut-and-cover aqueduct, being built by the Massachusetts Metropolitan District Commission, from the Outlet Works of Winsor Dam of the Quabbin Reservoir to the Chicopee city line. This aqueduct is 48 in. in diameter for about 24,000 ft from the Winsor Dam to a point on the west bank of the Swift River near the village of Bondsville, 36 in. in diameter for about 45,000 ft from that point to a 25-mil-gal storage reservoir at Nash Hill in Ludlow, and 36 in. in diameter for about 9,300 ft from the reservoir to the Chicopee city line. At the city line this aqueduct connects with a 36-in. main, about 18,000 ft long, being built by the city of Chicopee for connection with its Keating Hill standpipes.

INVESTIGATIONS AND LEGISLATION

Under Chapter 83 of 1945 the legislature passed a resolve under which a special commission, consisting of four members of the legislature, of members of the Metropolitan District Water Supply Commission, of the chief engineer of the State Department of Public Health, and of certain representatives of the water commissions of Springfield, Holyoke, Chicopee and Orange, was authorized to study the water-supply needs of municipalities situated in the valleys of the Connecticut, Chicopee, Swift, Ware, Quaboag and Millers rivers. This commission held public hearings and reported in House 1667 of 1946. The report indicated that it is not practicable to supply from the Quabbin Reservoir source communities located to the north in the Millers River valley, due to natural difficulties inherent in the topography, but also contained the accompanying plan (Figure 1) showing the approximate location of an aqueduct which could supply three of the larger municipalities interested at the time—namely, Chicopee, Palmer and Ware—and which could be extended as necessary to sup-

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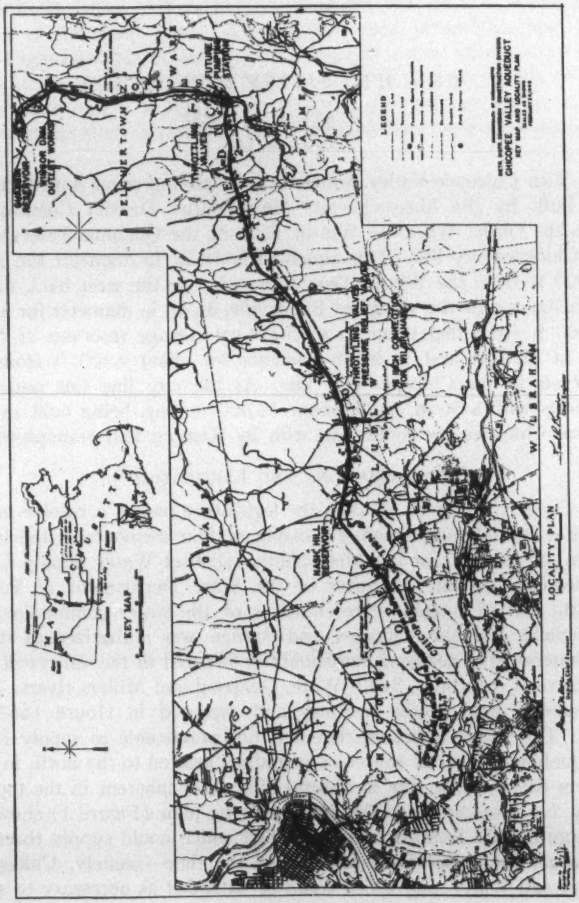

LEGEND
CHICOPEE VALLEY AQUEDUCT
KEY MAP AND LOCALITY PLAN
KEY MAP
LOCALITY PLAN
BELCHERTOWN
PALMER
WILBRAHAM
THROTTLING VALVES
FUTURE PUMPING STATION
NASH HILL RESERVOIR
THROTTLING VALVES
PRESSURE RELIEF VALVES
INCH CONNECTION FOR WILBRAHAM
CHICOPEE RESERVOIR
WINSOR DAM OUTLET WORKS

FIG. 1.

ply the needs of other interested municipalities, such as Holyoke, Wilbraham, etc.

Chapter 587 of 1945 not only reduced the cost of water to members of the Metropolitan Water District, but established a policy of fixing the price at $40 per mil gal to all members. The commission's report indicated that corresponding unit costs for water delivered from other points in the reservoir and aqueduct system would be $30 per mil gal from the Wachusett-Sudbury Reservoir-Aqueduct system and $20 from the Quabbin Reservoir and Aqueduct system.

The report in said House 1667 contained proposed legislation which would permit the Metropolitan District Commission to determine the fair cost, in addition to the $20-per-mil-gal base rate, to be charged at points along the aqueduct, such cost to depend not only on the cost of constructing and maintaining the new works, but also on the quantity of water which the district can reasonably expect to furnish from such an aqueduct system. The report indicated that the total cost might be about $60 to $65 per mil gal delivered to Chicopee or Palmer at its city or town line. In addition, there would be whatever capital and other costs the respective municipality would be called upon to bear, to deliver the water from its town line to, and make connections with, its local distribution lines.

In June, 1947, the legislature enacted Chapters 575 and 583 of 1947, which provided that the Metropolitan District Commission might expend such sums not exceeding $4,000,000 as may from time to time be approved by the Governor and Council, upon certification by said commission that satisfactory agreements had been made to supply an aggregate population of not less than 40,000 in the valley of the Chicopee River and its tributaries. This act provided for charging $20 per mil gal for water at Quabbin Reservoir, plus such sum as the Metropolitan District Commission may determine is appropriate to cover all capital and other costs of the system, and provided that this aqueduct system would be constructed of sufficient capacity to allow further extensions to meet the requirements of any city or town which it can reasonably supply with water.

The safe yield of the Quabbin-Wachusett-Sudbury supplies is nearly 330 mgd and the average consumption of the district in 1948 was 178 mgd, with a peak weekly average of 195 mgd, so that the

capacity of the system is adequate to supply the needs of the municipalities in the Chicopee River valley, consideration being given to both the estimated growth of the Metropolitan Water District and estimated increases in demand of communities that are now served or might be served in the metropolitan area.

The quality of water in Quabbin Reservoir is described in a paper presented to this association by Clarence H. Reed, Sanitary Engineer, Water Division, M.D.C., and published in the June, 1947, JOURNAL. It may be roughly summarized by the following characteristics: temperature (summer), 52°F. to 55°F.; turbidity, 1 ppm; color, 11-14 ppm (for 1946 and early 1947); manganese, 0 ppm; iron, 0.05 to 0.10 ppm; pH value, 6.5 to 6.7; dissolved oxygen, 8 to 12 ppm; alkalinity, 6 to 7 ppm; hardness, 15 to 16 ppm. The bacterial counts during filling of the reservoir were low and, after the long storage period since the filling, they are very low and the water is practically free of coli bacteria. The color of water in Quabbin Reservoir, as shown by two sampling stations—one near the Winsor Dam and the other near the intake of Quabbin Aqueduct—has improved yearly since 1940, probably due to the long-term storage of water in the large reservoir. If the samples within a range from which it would be reasonable to draw water for consumption are analyzed—that is, to depths not over 40 feet below the flow line—the following summary shows this marked improvement:

	Approximate color range (ppm)		
Year	*At Winsor Dam*	*At Quabbin Intake*	Remarks
1940	18-25	18-30	Reservoir filling
1941	17-25	17-30	" "
1942	14-18	16-19	" "
1943	13-17	16-18	" "
1944	15-17	16-17	" "
1945	12-17	12-17	Reservoir filled
1946	13-14	13-14	" "
1947	8-10	7-11	" "
1948	8- 9	8- 9	" "

Before and since the passage of said Chapters 575 and 583, very active interest has been shown by the legislators, city and town officials, manufacturers, interested citizens and others in the possibilities of obtaining water from Quabbin Reservoir. The Commission has

held hearings and many conferences with the officials and local committees of many communities, preparatory to the consideration of any desired agreements.

Agreements to Supply Water

Very shortly after the enactment of Chapter 575, the city of Chicopee made formal application as to the terms of an agreement that might be effected to furnish the city with its entire water supply. The Commission made reconnaissances and rough surveys, made soundings and test pits along the proposed location, located and investigated a distributing-reservoir site on Nash Hill in Ludlow, laid out a preliminary alignment and profile, made hydraulic studies and preliminary designs, and from these fundamental preliminary data made estimates of construction and maintenance costs.

In October, 1947, the Construction Division of the M.D.C. reported to the Commission that, based on September, 1947, prices, the estimated costs of an aqueduct to the Chicopee city line capable of caring for the needs of Chicopee, Palmer and Wilbraham with adequate capacity for expansion would probably be less than $3,500,000 and that construction could be effected to supply water to Chicopee in 1950, and it computed rates that would be a fair distribution of the costs between Chicopee and other prospective customers. This report was the basis of a preliminary agreement, made in December, 1947, which was revised somewhat in detail and superseded by a subsequent agreement in August, 1948, particularly to provide for construction of the water-connection main within the city of Chicopee by the city instead of by the Commission, and to provide for a 36-inch connection from Nash Hill Reservoir to the city line instead of a 30-inch connection, as previously planned. The act had provided that such construction within the city of Chicopee could have been made by the Commission if paid for by the city within a period of 10 years.

The terms of this latest agreement are mainly these:—

1. The Commission agrees to construct a pressure aqueduct with a carrying capacity of not less than 23 mgd and such other works as are necessary, or desirable, to meet the present and future requirements of such water supply to the City from Quabbin Reservoir to the Chicopee-Ludlow city line, and will maintain this aqueduct and

appurtenances and furnish the City with its water supply from Quabbin Reservoir through a distribution reservoir in Ludlow with a flow line at Elevation 425 (Boston City Base), a usable depth of 20 ft and a usuable capacity of approximately 23 mil gal, and by means of a 36-inch water main from this reservoir to the Chicopee city line.

The Commission agrees to reserve at all times in the distribution reservoir for the use of the City an average full day's supply of water. Freedom from objectionable algae and other vegetation will be maintained in the Nash Hill Reservoir at all times, with chemical treatment if needed. The water to be supplied from Quabbin Reservoir will not be "bottom" water, but will be the best water available and will be generally drawn at depths down to 30 ft from the flow line.

Estimates show that such an aqueduct will be capable of delivering water at the Chicopee city line, Elevation 240 more or less, at the following pressures for the conditions of flow line of reservoir and rates of consumption given:

Distribution-reservoir flow-line elevation (Boston City Base)	Rate of consumption	Approximate hydrostatic pressure in pipe at Chicopee city line
425	6 mgd	80 lb. per sq in.
425	11 "	77 " " " "
425	16 "	73 " " " "
420	6 "	77 " " " "
420	11 "	74 " " " "
420	16 "	71 " " " "

2. The City agrees to construct a 36-inch pipe line from the Chicopee-Ludlow city line, at or near Burnett Rd., to the existing standpipe of the City, the cost of which will be borne by the City, and which will be maintained by the City.

3. The Commission will render, and the City will pay, quarterly bills for quantities of water delivered to the City at the city line, as measured by a Venturi meter maintained by the Commission, and as computed in accordance with the following terms and schedule of rates:

(a) The City will guarantee the payment of a minimum annual charge of $100,000, regardless of the quantity of water used;

(b) In any calendar year when the average quantity of water

furnished by the Commission is less than 8 mgd the price per mil gal will be $62.75, but in no event will the yearly cost to the City exceed the sum of $171,000 for this average quantity;

(c) In any calendar year when the average quantity of water furnished by the Commission is 8 mgd or more, and less than 9 mgd, the price per mil gal will be $58.60, but in no event will the yearly cost to the City exceed the sum of $179,000 for this average quantity;

(d) In any calendar year when the average quantity of water furnished by the Commission is 9 mgd or more, and less than 10 mgd, the price per mil gal will be $54.50, but in no event will the yearly cost to the City exceed the sum of $184,000 for this average quantity;

(e) In any calendar year when the average quantity of water furnished by the Commission is 10 mgd or more, the price per mil gal will be $50.40.

(f) All of the above prices per mil gal are subject to a reduction of 50 cents for each calendar year beginning with the eleventh full calendar year of such furnishing of water by the Commission to the City, until the price is reduced to $40.40 per mil gal.

4. It is further mutually agreed that this agreement will continue for a period of 50 years after the water is first furnished to the City; provided, however, that the City will have the right of extension for such periods of time and at such terms as shall be mutually agreed upon by the Commission and the City.

5. The Commission agrees to begin the construction herein set forth within a reasonable time after the execution of this agreement and thereafter to prosecute the construction diligently and continuously, and to make every reasonable effort to make water available in quantities desired under the agreement by December 31, 1949, and notice of the terms of any extension of time allowed the constructor shall be made known promptly to the City.

In February, 1948, the Commission also made an agreement with the town of Wilbraham to furnish it with water at the following rates:

(a) The Town will guarantee the payment of a minimum annual charge of $2,000 regardless of the quantity of water used;

(b) The price per mil gal will be $67 in each of the first ten years following the first use of the completed works;

(c) The above price per mil gal will be subject to a reduction thereafter of 50 cents for each year, until the price is reduced to $45 per mil gal.

In addition, conferences with other municipalities have been held and other agreements may be made from time to time, as other municipalities decide that such agreements are desirable.

Computation of Rates in Agreements

The basis of the rates in the agreements was (1) $20 per mil gal for water at Quabbin Reservoir, (2) payment of fixed charges on the share of the construction cost as distributed over 50 years for the meeting of the bonded indebtedness, that share being determined by the capacity reserved for the anticipated needs of the municipality for the next 50 years, and (3) the payment of a fair share of the future maintenance costs.

The rates are made on a sliding scale, so that the charges may be equitably distributed in accordance with the quantities of water used. The minimum annual guarantee protects the Commission against loss, in case the amounts of water used are inadequate to carry the fixed and maintenances charges, and permits, with such protection, the fixing of lower and fairer rates per mil gal for water consumed.

Description and Design

As the city of Chicopee desires water by 1950, the Commission decided to purchase the pipe for the construction at the earliest practicable date, so that the manufacture and delivery of it would not delay progress of the work before the construction contracts could be prepared and awarded.

Accordingly, hydraulic and other designs based on the preliminary plan and profile progressed at the same time that the field work on more accurate topographic and real estate surveys was conducted.

As this aqueduct will be the sole feeder of Quabbin water to the communities served, primary consideration was given to permanency of construction, as the aqueduct cannot be shut down for renovation or repairs requiring more than a day or two in time. The Commission decided to require construction of one of three types: (1) cement-lined cast iron with exterior bituminous coating, (2) steel-plate pipe,

mortar-lined, with exterior bituminous coating and (3) reinforced-concrete, steel-cylinder pressure pipe.

The 1947 water consumption indicated that Chicopee would require at present rates about 6 mgd, Wilbraham about 0.13 and Palmer about 0.87, or a total of 7 mgd. Chicopee indicated that it had ambitious plans for expansion, particularly into industrial fields, and that a future capacity requirement of 12 to 15 mgd should be provided. With reasonable allowances for future expansion, the Commission decided that it would not be advisable to build the aqueduct from Winsor Dam to Bondsville less than 48 in. in diameter and from Bondsville to Nash Hill Reservoir 36 in. in diameter, and, as Chicopee decided to build a 36-inch main within the city limits, the Commission agreed to build the connection from Nash Hill Reservoir to the city line 36 in. in diameter, instead of 30 in. as it had at first considered.

Figure 2 shows a chart upon which are plotted the hydraulic gradients, showing carrying capacities of the aqueduct and the relation of the gradients to the topography. Hazen and Williams' c is assumed to be 135.

The alignment chosen runs from the Outlet Works at Winsor Dam down the south side of the Outlet Channel to the Swift River for about 1,500 ft on land already owned by the Commission, then crosses the river and runs down the east side of the river to Bondsville, about 12,200 ft on land already owned by the Commission, largely along the abandoned roadbed of the Athol branch of the Boston and Albany Railroad, and about 3,500 ft mainly along the river road and about 5,800 ft mainly across former private property to the site of a control station, to which a future pumping station for Palmer and Ware supplies may be later added, thence southwesterly about 1,000 ft across the Swift River to two 36-inch branches, one for future use if needed and one for present use. From one branch a 36-inch line extends westerly mainly across former private property for about 22,600 ft to a point near the intersection of Alden St. and Belchertown Rd. in the town of Ludlow, thence westerly along Belchertown Rd. for about 10,000 ft to a pressure-control and relief station, thence westerly about 7,800 ft along Belchertown Rd. through Ludlow Center and along Church St. to a point near Munsing St., thence westerly across former private property about 4,600 ft to the site of Nash Hill Reservoir on

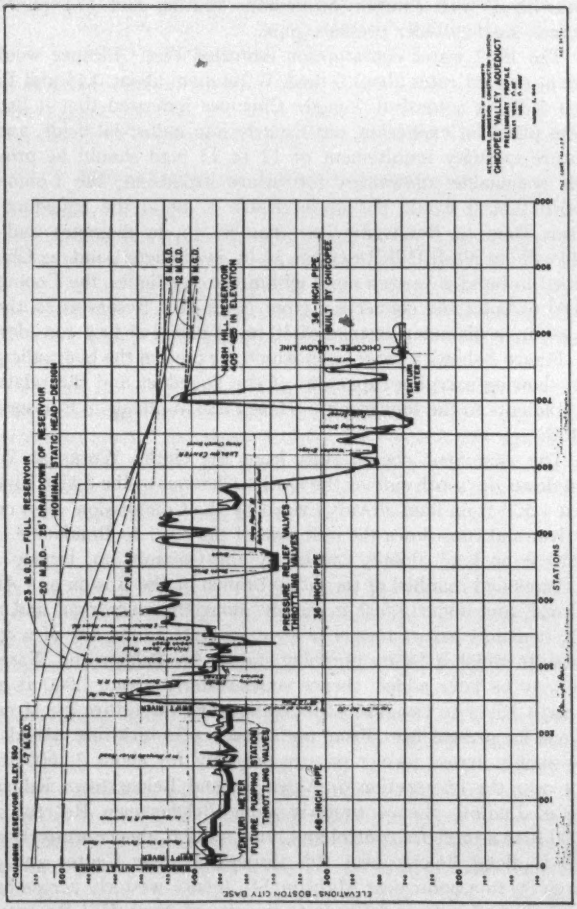

CHICOPEE VALLEY AQUEDUCT
PRELIMINARY PROFILE
23 M.G.D.—FULL RESERVOIR
20 M.G.D.—25' DRAWDOWN OF RESERVOIR
NOMINAL STATIC HEAD—DESIGN
6 M.G.D.
12 M.G.D.
18 M.G.D.
NASH HILL RESERVOIR
405-425 IN ELEVATION
36-INCH PIPE
BUILT BY CHICOPEE
CHICOPEE-LUDLOW LINE
VENTURI METER
PRESSURE RELIEF VALVES
THROTTLING VALVES
36-INCH PIPE
48-INCH PIPE
VENTURI METER
FUTURE PUMPING STATION
THROTTLING VALVES
SWIFT RIVER
WINSOR DAM—OUTLET WORKS
STATIONS
ELEVATIONS-BOSTON CITY BASE

FIG. 2.

the top of Nash Hill, thence southwesterly about 8,100 ft across private property and about 1,200 ft along Burnett Rd. to the Chicopee city line.

Quabbin Reservoir has a flow line when filled of 530 (Boston City Base) and Nash Hill Reservoir of 425. The location in profile is such that the aqueduct flows under pressure for its entire length. The aqueduct line follows the contour of the ground, with air valves in the summits and blowoff provisions in low sections between summits.

Flow in the aqueduct is throttled by two 24-inch-by-16-inch needle valves at the control station near Bondsville and by two 16-inch-by-12-inch needle valves in a control station in Belchertown Rd., at which latter station two 9-inch pressure-relief valves are provided, to prevent excessive pressures from developing in case of improper regulation of the throttling controls, of failure of the throttling equipment to function properly or of other unforeseen conditions. This relief prevents the pressure gradient from rising above Elevation 485 at that location. The Nash Hill Reservoir under normal operating conditions rides on the pipe-line gradient and helps to equalize and maintain the gradient at that location. In the reservoir gatehouse is provided an overflow weir which prevents the gradient there from rising appreciably above Elevation 425, regardless of the manipulation of the throttling controls. Gates are also provided for cutting off the reservoir from the aqueduct entirely, for draining and cleaning, if such procedure seems desirable.

Ordinarily the entire aqueduct rides freely on the Quabbin and Nash Hill Reservoirs, with control of flow maintained at the two throttling, needle-valve stations. A guard gate valve is provided at the head of the aqueduct line, which is connected to both the 68-inch and 48-inch conduit lines installed from the Intake Works through Winsor Dam to the Outlet Works.

Screens are provided for installation at the Intake Works of Winsor Dam and at the Nash Hill gatehouse, to prevent any leaves or trash from Quabbin or Nash Hill Reservoirs from entering the aqueduct.

A 48-inch-by-16-inch Venturi meter is provided near the Outlet Works, for measuring the total flow drawn from Quabbin Reservoir. A second Venturi meter will be installed near the Chicopee city line,

to measure the water delivered to the city. This is a 24-inch-by-9-inch meter, designed to be readily revised into a 24-inch-by-12-inch meter by the insertion of new throat and downstream tube castings, and there are provisions for bypassing the meter at the time such installation is made. Other connections to the aqueduct will be metered when made: for example, a 16-inch connection for furnishing water to Wilbraham contains a 6-inch-by-2-inch compound water meter and recorder.

Access inspection manholes are furnished generally not more than 1,500 feet apart and future side connections with valves at main highways are liberally provided.

The city of Chicopee plans to build a treatment station in a proposed building at the city line, providing for chlorination and Calgon treatment, and it is anticipated that a separate room in this building, wall-sealed from other rooms, will provide space for housing the meter recorder of the Commission.

Purchase of Pipe and Equipment

Early in 1948, arrangements were in progress to purchase the pipe for the aqueduct. Specifications were prepared and the Purchasing Bureau of the Commission on Administration and Finance opened bids on April 7, 1948. Proposals on three types of pipe were invited by public advertisement as follows:

1. About 24,000 linear feet of 48-inch bell-and-spigot cast-iron pipe, about 45,000 linear feet of 36-inch bell-and-spigot cast-iron pipe, and about 25,000 linear feet of 30-inch bell-and-spigot cast-iron pipe (about 8,000 ft of type I and 17,000 ft of type II) were specified. The following is a tabulation of the sizes and weights:

Size, Thickness and Weight of Cast-Iron Pipe

Nominal diameter	AWWA Standard Class	AWWA Standard Thickness	AWWA Standard Weight per foot	ASA Standard Class	ASA Standard Thickness Dimension	ASA Standard Weight per foot
48-inch	B	1.42″	750.0 lb.	3	1.37″	726.3 lb.
36-inch	B	1.15″	454.2 “	3	1.13″	449.2 “
30-inch—I	B	1.03″	333.3 “	3	1.02″	335.0 “
30-inch—II	C	1.20″	400.0 “	5	1.19″	402.9 “

Each pipe was to be lined with cement mortar, with a bituminous seal-coat and coated with a coal-tar dip. Bends, tees, manhole sections, sleeves and other fittings were included.

2. About 24,000 linear feet of 48½-inch, welded steel-plate pipe, ⅜-inch thick; about 45,000 ft of 36½-inch, welded steel-plate pipe, 5/16-inch thick; and about 25,000 ft of 30½-inch, welded steel-plate pipe, of which 8,000 ft were to be ¼-inch and 17,000 ft 5/16 inch thick, in lengths of 34 to 45 ft and with Dresser couplings, were specified. Each pipe was to be delivered unpainted and uncoated on the inside, as the finished aqueduct was to be cement-mortar-lined by others, but was to be coated on the outside with two coats, a primer and a finishing coat of an approved coal-tar product. Curves, flanged connections, covers and other specials were included.

3. About 24,000 linear feet of 48-inch, about 45,000 linear feet of 36-inch and about 25,000 linear feet of 30-inch reinforced-concrete pressure pipe, meeting the requirements of the tentative specification of the American Water Works Association, 7B.1-T-1947, for reinforced-concrete steel-cylinder pressure pipe (not prestressed), but requiring the use of the so-called "Merriman" cement in the manufacture. Flanged connections, manhole frames and covers, anchorage connections, bevelled-end pipe for curves, closure sections and other specials were specified.

These types were not bidding in direct competition with each other, as evaluation of the proposals had to be made, such variable and differential factors being borne in mind as carrying capacities, handling, jointing, laying, leakage, specials, maintenance, cost of appurtenant structures, anchorages and stiffeners, mortar-lining of the steel pipe, which was to be done by others upon completion of the installation, durability, depreciation, etc.

No bid was received on the cast-iron pipe and one bid on the reinforced-concrete pressure pipe. One bid with two alternates as to linings and coatings on the steel pipe was received, all steel-pipe bids subject to a 10% escalator clause.

The contract for furnishing and delivering the pipe was awarded to the Lock Joint Pipe Co., of Ampere, N. J., whose bid in the sum of $1,412,750 was a firm one and without doubt the lowest with any reasonable evaluation for the above factors, even without consideration of the escalator clause.

This company erected a manufacturing plant in Palmer and to May 14, 1949, had manufactured 23,152 ft of 48-inch and 43,872 ft of 36-inch pipe. The contract requires delivery of the pipe on certain specified storage areas, distributed along the aqueduct line, and on that date the company had delivered 21,456 ft of 48-inch pipe on Section 1, and 18,672 ft of 36-inch pipe on Section 2, 16,864 ft on Section 3 and 4,208 ft on Section 4. The manufacturer in its proposal agreed to complete delivery of all pipe before September 1, 1949, and it is now anticipated that it will be practically completed well before that time, probably by the middle of June, 1949.

Serious consideration was given to the possible use of prestressed reinforced-concrete pipe without a steel cylinder but, due to several factors—particularly that the aqueduct is a sole feeder to the Chicopee Valley area; durability and very long life are primary requisites; shutdown for major repairs almost an impossibility; the lack of experience records with this type of pipe on other similar projects; the inability of the prestressing manufacturer to purchase concrete cores for prestressing of guaranteed consistent impermeability, capable of satisfactorily withstanding the desired hydrostatic testing of each pipe length; and the anticipated use of joints of a design which had not been already demonstrated to be satisfactorily tight and durable in service—the Commission did not request bids on this type, although it is the author's opinion that this product has considerable possibilities for use in future pipe-line construction, particularly where the diameters are small, the pressures low, and the dependability and long-term durability are not as important factors as in this case.

On February 10, 1949, the Commission opened bids on Contract 165, for furnishing and delivering screens, gate valves, sluice gates, pressure-reducing valves, pressure-relief valves, air-valves, air-cocks, crane hoist, Venturi meters and recorders, compound water meter and recorder, hydrant and water-level recording gauge for the Chicopee Valley Aqueduct, and awarded each contract to the low bidder.

A contract for 29 screens, each screen consisting of a rectangular, galvanized, welded, structural-steel frame, supporting a bronze, No. 14 gauge, ½-inch mesh, was awarded to Arco Welding and Machine Works, Inc., of Jersey City, N. J., in the sum of $4,770.50.

A contract for one 48-inch, two 36-inch, two 30-inch, nine 24-

inch, three 20-inch, eight 16-inch, twenty-one 12-inch, three 10-inch, sixty-two 8-inch, six 6-inch, twenty-five 4-inch and twelve 2½-inch gate valves and one 10-inch check valve was awarded to The Chapman Valve Manufacturing Co. of Indian Orchard, Mass., in the sum of $57,917.00.

A contract for two sluice gates—one 42-inch and one 36-inch—with extension stems and floor stands was awarded to The Chapman Valve Manufacturing Co. of Indian Orchard, Mass., in the sum of $4,621.00.

A contract for two 24-inch-by-16-inch and two 16-inch-by-12-inch needle valves was awarded to The Pelton Water Wheel Co. of San Francisco, Cal., in the sum of $50,300.00.

A contract for two 9-inch pressure-relief valves and controls was awarded to The Lombard Governor Corp. of Ashland, Mass., in the sum of $3,855.00.

A contract for 12 automatic pressure-relief air valves, for 30 combination pressure-relief and 4-inch vacuum air vales, and for 2 combination pressure-relief and 6-inch vaccum air valves was awarded to the Simplex Valve and Meter Co. of Philadelphia, Pa., in the sum of $5,426.00.

A contract for 7 manual air-cocks was awarded to the Multiplex Manufacturing Co., Inc., of Berwick, Pa., in the sum of $702.80.

A contract for a 48-inch-by-16-inch and a 24-inch-by-9-inch Venturi meter with recorders was awarded to Builders-Providence, Inc., of Providence, R. I., in the sum of $9,704.00.

A 2-ton crane hoist for the Nash Hill Gatehouse was also purchased from Robert Abel, Inc., of Boston, Mass., at a bid price of $2,326.00; a 6-inch-by-2-inch compound water meter and recorder from R. W. Sparling, Boston, Mass., at a bid price of $1,000.00; and a water-level recording gauge from Leupold & Stevens of Portland, Ore., at a bid price of $198.00.

Real Estate and Rights-of-Way

Real estate surveys were made mainly during the summer of 1948 and taking plans were made, dated September 23, 1948, for Section 1 and November 15, 1948, for Sections 2 and 3. A permanent easement generally 50 ft wide was taken across private property, with

additional temporary easements for construction purposes, particularly for access to the construction work across private property and for storage of pipe, as needed. These latter temporary takings could not anticipate the needs of access and storage too well in advance, so that it has been necessary to make temporary easement takings from time to time as the work progressed.

Construction Contracts

In order that the 15 miles of aqueduct might be expeditiously built in approximately one construction season, the work was divided into four parts, named Sections 1 to 4, inclusive.

Bids for Section 1 (Contract 166), which work consists of constructing about 24,000 ft of cut-and-cover aqueduct, using 48-inch inside-diameter reinforced-concrete pressure pipe in 16-foot lengths, furnished by the Commission, and includes the building of appurtenant structures, such as the throttling-valve chamber near Bondsville, the connection to the Outlet Works at Winsor Dam, the installation of the 48-inch-by-16-inch Venturi meter and other equipment, the building of blowoffs, manholes, culverts, highway crossings and two crossings of the Swift River, etc., were opened on September 30, 1948, and the contract was awarded to the low bidder, Charles F. Smith & Son, Inc., of Dayton, O., in the sum of $460,530.00 The notice to begin work was dated January 3, 1949, and completion of the pipe line, ready for testing, by March, 1950, is required. On May 14, 1949, the contractor had laid 7,984 ft of pipe.

Bids for Sections 2 and 3 (Contracts 167A and 167B), which work consists of constructing about 22,500 ft on Section 2 and 22,500 ft on Section 3 of cut-and-cover aqueduct, using 36-inch inside-diameter reinforced-concrete pressure pipe in 16-foot lengths, furnished by the Commission, and includes the building of throttling-valve and pressure-relief chambers, blowoffs, manholes and culverts, the installation of valves and other equipment, highway, railroad and brook crossings, work on highway regrading and resurfacing, and also the construction on Miller St. in Ludlow of a 16-inch pipe line about ½-mile long, connecting the aqueduct with a distribution main belonging to the town of Wilbraham, and the construction of a 20-inch pipe overflow about 2,000 ft long, to care for any spillway overflow at Nash

Hill Reservoir, were opened November 23, 1948. The proposal forms provided for bidding on work of either one or both sections, the award to be made to the lowest combination, but the work being required to progress on both sections simultanously. The contract numbered 167 was awarded to the low bidder, the Allied Engineering Corp., Boston, Mass., for both sections combined, in the sum of $897,457.93. The notice to begin work was dated January 27, 1949, and completion of the pipe line in operating condition is required by February, 1950. On May 14, 1949, the contractor had laid 2,928 ft on Section 2 and 1,600 ft on Section 3.

Bids for Section 4 (Contract 168), which consists of constructing about 9,000 ft of cut-and-cover aqueduct, using 36-inch inside-diameter reinforced-concrete pressure pipe in 16-foot lengths, furnished by the Commission, of constructing an open storage reservoir of about 25-mil gal capacity, formed by earth excavations and embankments, of constructing the Nash Hill gatehouse foundations and superstructure and the connecting steel-plate, concrete-encased, mortar-lined conduits, of installing equipment, of placing riprap, stone and concrete protections on the reservoir embankments and the construction of an access road to the gatehouse, and aqueduct manholes, culverts, blowoffs and appurtenant structures, were opened on March 24, 1949. The contract was awarded to the low bidder, G. Rotondi & Sons of Melrose, Mass.. in the sum of $488,764.25. On May 14, 1949, the Contractor had started work. Completion of the aqueduct and reservoir, ready for operation, is required by February, 1950.

Work on these contracts is proceeding energetically and it is anticipated that the aqueduct will be ready to deliver water very early in 1950, if not sooner. The Contractor on Section 1 is very experienced in this work and is making good progress. The work is somewhat new to the Contractor on Sections 2 and 3. Hence, although his progress to date has not been as good, it is anticipated that it will pick up considerably soon.

Unit Construction Costs

Pipe Delivered (Proposal Prices)

	48-inch Design head			36-inch Design head					
	150	170	190	100	120	140	160	180	200
Straight pipe, 16 ft long—per lin. foot	$20.25	$20.70	$21.10	$12.70	$12.80	$13.00	$13.40	$13.60	$13.80
			4"	6" or 8"		12"	16" or 18"		24"
Per flanged connection			$105.00	$115.00		$125.00	$145.00		$185.00

Per manhole frame and cover	$200.00
Per anchorage connection	8.00
Per beveled end—48" pipe	16.00
Per beveled end—36" pipe	12.00
Per closure section—48" pipe	160.00
Per closure section—36" pipe	120.00

Equipment Delivered (Approximate Bid Costs)

Screen—4½-ft-by-5-ft frame	$ 164.50 each
48-inch valve with self-contained operating stand	7,900.00 each
36-inch gate valve	3,864.00 each
30-inch gate valve	2,675.00 each
24-inch gate valve	1,691.00 each
20-inch gate valve	1,176.00 each
12-inch gate valve	195.00 each
10-inch gate valve	139.00 each
8-inch gate valve	84.00 each
6-inch gate valve	57.00 each
4-inch gate valve	38.00 each
2½-inch gate valve	26.00 each
42-inch sluice gate and stand	2,747.00 each
36-inch sluice gate and stand	1,874.00 each
24"x16" needle valve	17,000.00 each
16"x12" needle valve	8,150.00 each
Two 9" pressure-relief valves and appurtenances	3,855.00
Pressure-relief air valve	38.00 each
4" vacuum air valve with pressure relief	151.30 each
6" vacuum air valve with pressure relief	215.50 each
Manual air-cock	100.40 each
48"x16" Venturi meter and recorder	5,750.00 each
24"x9" Venturi meter and recorder	3,954.00 each
6"x2" compound meter and recorder	1,000.00 each

PIPE LAYING AND TRENCH WORK (Unit Bid Price)

	Unit	Sections			
		1	2	3	4
Clearing	acre	$300.00	$ 700.00	$ 700.00	$ 400.00
Grubbing	acre	600.00	1,500.00	1,500.00	1,500.00
Stripping	cy	0.60	0.60	0.60	0.55
Earth excavation	cy	1.30	1.60	1.60	1.35
Rock excavation	cy	5.00	4.50	4.50	1.35
Compacted refill and embankment	cy	0.30	0.40	0.40	1.00
Other refill and embankment	cy	0.30	0.15	0.15	0.30
Soil dressing	cy	0.60	1.00	1.00	0.80
Seeding and grassing	acre	50.00	500.00	500.00	500.00
Gravel	cy	3.00	1.50	1.50	1.00
Crushed stone and screened gravel	cy	3.00	4.50	4.50	4.25
Paving	cy	11.00	7.00	7.00	20.00
Riprap	cy	3.50	10.00	10.00	6.00
Concrete in pipe foundation	cy	20.00	34.00	34.00	17.00
Reinforced concrete	cy	45.00	50.00	50.00	50.00
Reinforcing steel	lb	0.15	0.10	0.10	0.12
Portland cement	bbl	5.00	4.50	4.50	5.00
Brick masonry	cy	40.00	90.00	90.00	100.00
Cobble gutters	cy	20.00	20.00	20.00	20.00
Permanent fencing	lin ft	1.30	1.50	1.50	1.50
Caring for, laying, jointing and testing 48″ pipe	lin ft	1.50			
Caring for, laying, jointing and testing 36″ pipe	lin ft		4.25	4.25	3.00
Caring for and installing equipment	lb	0.02	0.04	0.04	0.05

SPECIAL STRUCTURES

Nash Hill Reservoir and Gatehouse

The Nash Hill storage reservoir has a filled capacity of 25 mil gal. It has a flow line at Elevation 425 and a bottom at about Elevation 405. A capacity curve is shown in Figure 3. The reservoir is formed on the summit of Nash Hill, where the original ground surface is about Elevation 408 at the reservoir edges and Elevation 413 at the summit of the hill, by excavating to Elevation 405 and using the excavated and other materials nearby to form a continuous embankment dam, with top at about Elevation 430. The materials beneath the top soil are mainly brownish glacial tills, probably containing many stones and boulders. Figure 4 shows a grain-size analysis curve of this material, which has a permeability of about 15,000 gal per acre per day for a slope of unity.

SUMMARY—COSTS PER LINEAR FOOT (AVERAGE)

	Section 1 24,000′ of 48-inch 150′-150′ head	Section 2 22,500′ of 36-inch 100′-180′ head	Section 3 22,500′ of 36-inch 100′-200′ head	Section 4 9,000′ of 36-inch 100′-200′ head
Cost of pipe delivered	$21.00	$13.48	$13.61	$13.64
Cost of laying, jointing and testing	1.50	4.25	4.25	3.00
Cost of trench and earthwork	11.52	9.18	9.98	5.20
Cost of appurtenant structures	4.15	3.11	3.12	2.50
Cost of equipment	2.62	0.72	1.37	1.30
Extra cost of 2 river crossings and Outlet Works connections	2.21			
Highway surfacing, brook and highway crossings		0.45	3.30	0.50
	$43.00	$31.19	$35.63	$26.14
In addition, on Section 3, 2,100′ of 20-inch overflow pipe and 2,500′ of 16-inch connection pipe			2.44	
			$38.07	
In addition, on Section 4, a 25-mil gal open storage reservoir with gatehouse, steel plate conduit connections to the aqueduct and gate controls, costing about				$16,000 per mil gal of storage

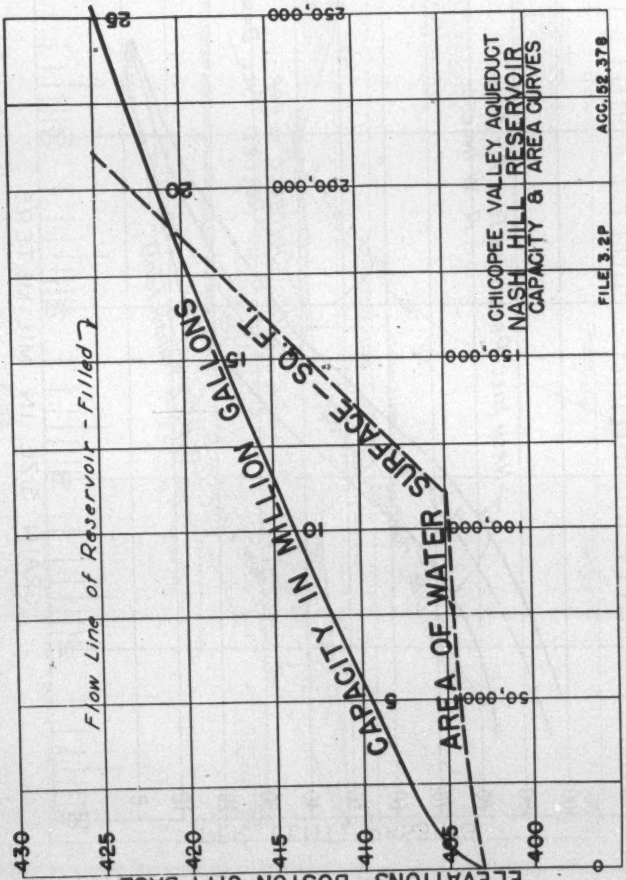

ELEVATIONS - BOSTON CITY BASE
430
425
420
415
410
405
400
0
CAPACITY IN MILLION GALLONS
AREA OF WATER SURFACE - SQ. FT.
25
20
15
10
5
0
250,000
200,000
150,000
100,000
50,000
0
Flow Line of Reservoir - Filled
CHICOPEE VALLEY AQUEDUCT
NASH HILL RESERVOIR
CAPACITY & AREA CURVES
FILE 3.2P
ACC. 52.378

FIG. 3.

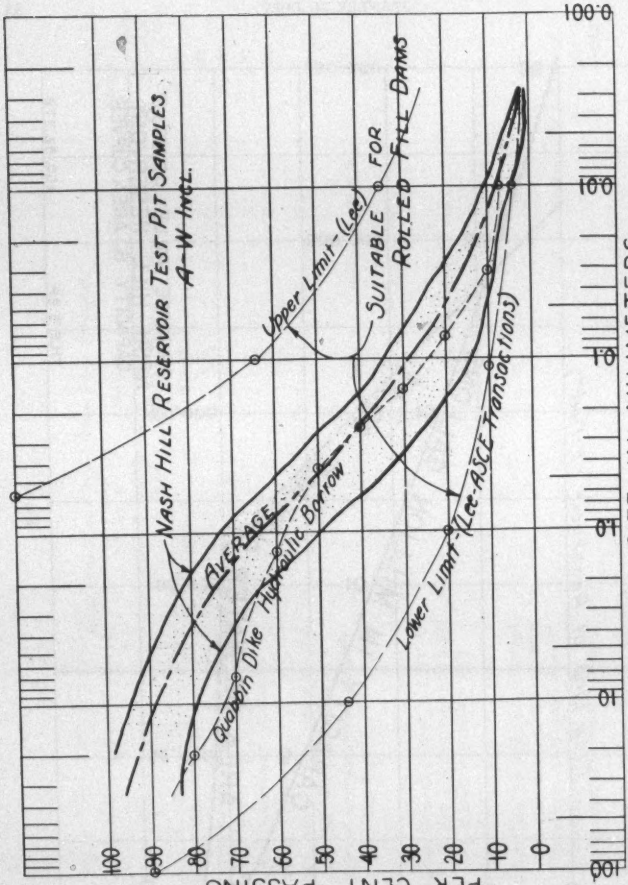

PER CENT PASSING
100
90
80
70
60
50
40
30
20
10
0
GRAIN SIZE IN MILIMETERS
100.0
10.0
1.0
0.1
0.01
NASH HILL RESERVOIR TEST PIT SAMPLES. A-W INCL.
AVERAGE
Quabbin Dike Hydraulic Borrow
Upper Limit-(Lee)
SUITABLE FOR ROLLED FILL DAMS
Lower Limit-(Lee-ASCE Transactions)

FIG. 4.

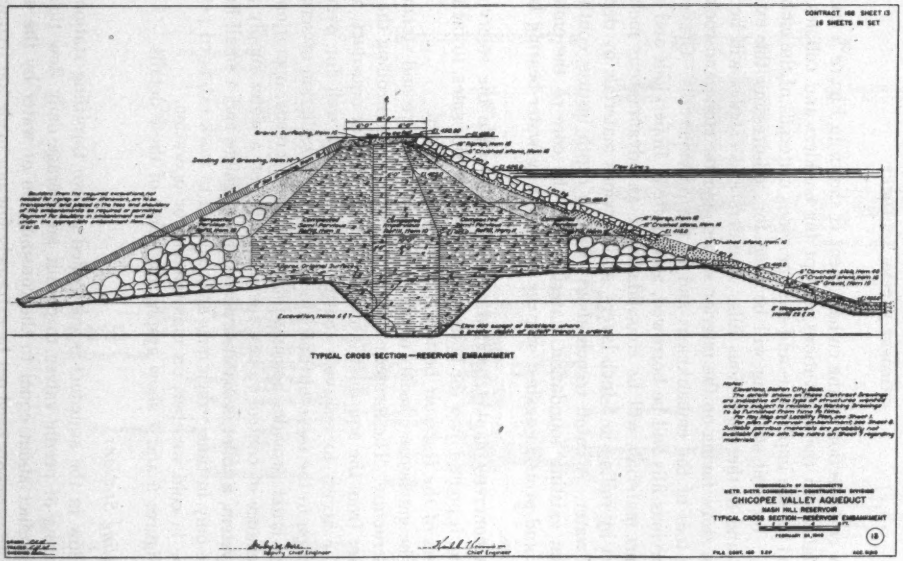

CONTRACT 100 SHEET 13
16 SHEETS IN SET
TYPICAL CROSS SECTION—RESERVOIR EMBANKMENT
COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. COMMISSION—CONSTRUCTING DIVISION
CHICOPEE VALLEY AQUEDUCT
WASH HILL RESERVOIR
TYPICAL CROSS SECTION—RESERVOIR EMBANKMENT
Chief Engineer

FIG. 5.

A cross-section of the embankment is shown in Figure 5 and the materials from the excavations, except for boulders and cobbles, will be used for the impervious and semi-pervious materials of the embankments. Top-soil stripping will be used for soil-dressing the exterior slopes and in the impervious fills. Boulders and cobbles will be used for the stone facing on the interior slopes, and for stone and rock fills in the toes of the embankment and in the pervious fills. Gravel for the pervious fills will be borrowed, as required. Impervious and semi-pervious materials will be consolidated at an advantageous moisture content by rolling in 6-inch layers, and pervious materials by depositing in water. A cutoff trench about 10 ft in depth insures continuity between existing foundation materials and the core of the embankments and protects against seepage through any water-bearing layers or lenses.

A concrete blanket, vented against uplift when the reservoir is drained, is poured over the bottom and lower interior sides, to facilitate cleaning of the reservoir bottom, if and when desired.

The gatehouse consists of a concrete substructure and stonework superstructure. The former provides wet wells for controlling the flow of water from the aqueduct into the reservoir and/or aqueduct, a dry well for access to reservoir control valves, a dry well for overflow protection to the reservoir and grooves for the installation of screens; and the latter provides housing for cleaning of screens, operation and maintenance of control valves, for a crane hoist, a water-supply pressure system, a toilet, a water-level recording gauge and a small heater for use only in times when men are required to work extended periods of time in cold weather, on maintenance or operation.

Figures 6 and 7 show graphically some of these details.

Throttling Stations

Flow in the aqueduct is controlled at two throttling stations by the setting of needle valves to permit an average daily flow through the aqueduct about equal to the consumption of water by the users. These adjustments need not be extremely fine nor made too frequently, because the available storage in Nash Hill Reservoir will care for hourly and even daily differences, if they are not too large.

The control structure on Belchertown Rd. (Figure 8) is really a

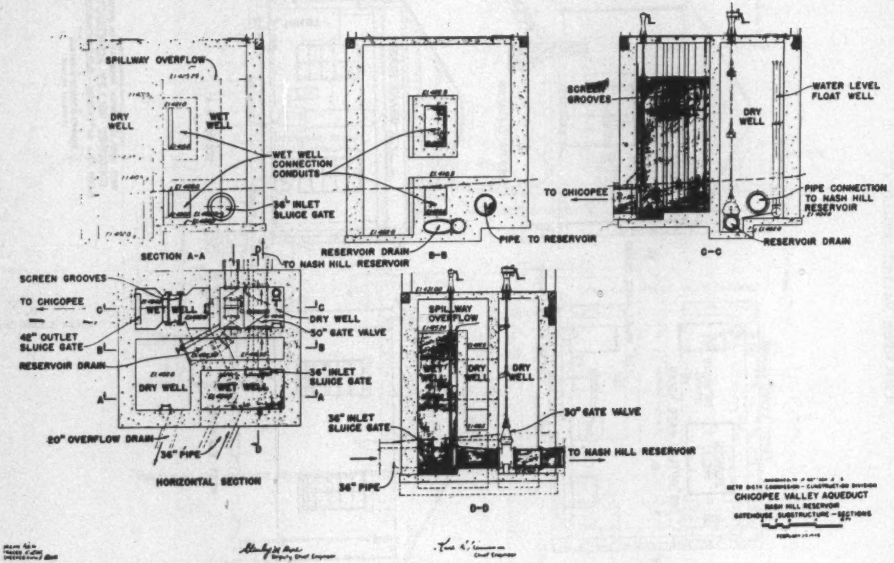

SPILLWAY OVERFLOW
DRY WELL
WET WELL
WET WELL CONNECTION CONDUITS
36" INLET SLUICE GATE
SECTION A-A
RESERVOIR DRAIN
B-B
PIPE TO RESERVOIR
SCREEN GROOVES
WATER LEVEL FLOAT WELL
DRY WELL
TO CHICOPEE
PIPE CONNECTION TO NASH HILL RESERVOIR
RESERVOIR DRAIN
C-C
TO NASH HILL RESERVOIR
SCREEN GROOVES
TO CHICOPEE
48" OUTLET SLUICE GATE
RESERVOIR DRAIN
DRY WELL
WET WELL
30" GATE VALVE
36" INLET SLUICE GATE
20" OVERFLOW DRAIN
36" PIPE
HORIZONTAL SECTION
SPILLWAY OVERFLOW
DRY WELL
DRY WELL
30" GATE VALVE
36" INLET SLUICE GATE
TO NASH HILL RESERVOIR
36" PIPE
D-D
CHICOPEE VALLEY AQUEDUCT
NASH HILL RESERVOIR
GATEHOUSE SUBSTRUCTURE — SECTIONS

FIG. 6.

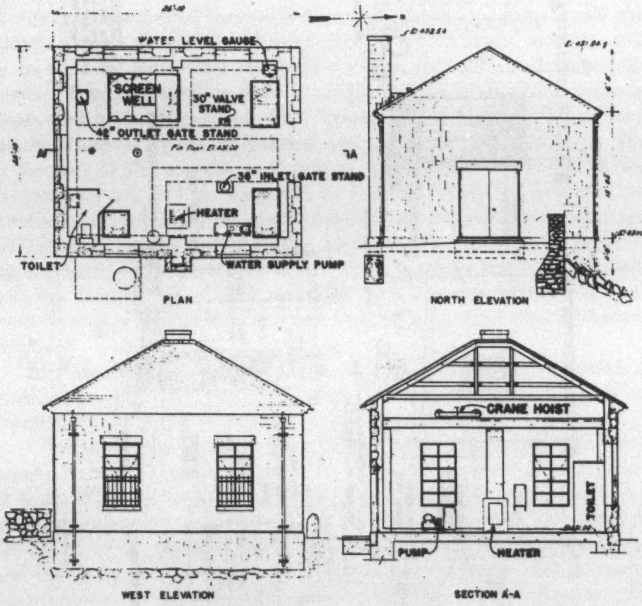

WATER LEVEL GAUGE
SCREEN WELL
30" VALVE STAND
48" OUTLET GATE STAND
36" INLET GATE STAND
HEATER
TOILET
WATER SUPPLY PUMP
PLAN
NORTH ELEVATION
CRANE HOIST
TOILET
PUMP
HEATER
WEST ELEVATION
SECTION A-A
CHICOPEE VALLEY AQUEDUCT
RASH HILL GATEHOUSE — SUPERSTRUCTURE
FEBRUARY 26, 1940

FIG. 7.

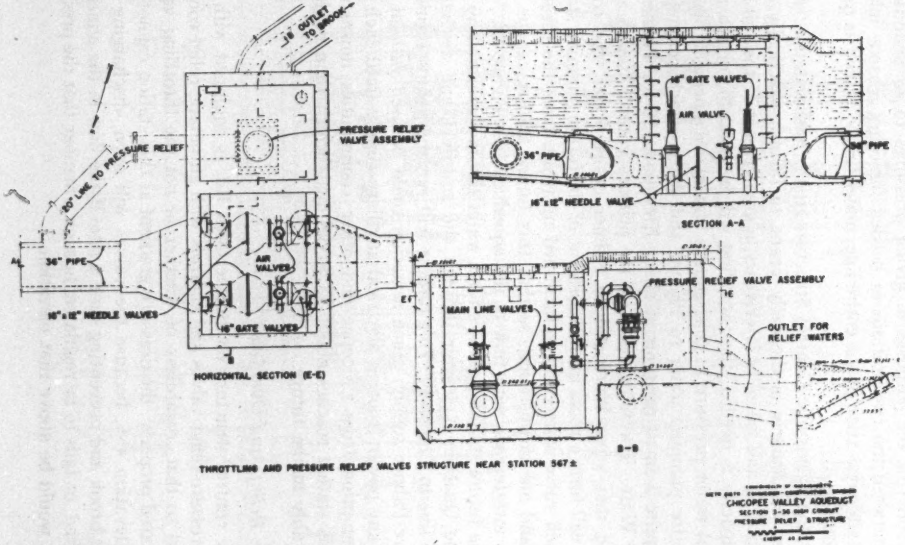

18" OUTLET TO BROOK
PRESSURE RELIEF VALVE ASSEMBLY
30" LINE TO PRESSURE RELIEF
36" PIPE
AIR VALVES
16"x12" NEEDLE VALVES
16" GATE VALVES
HORIZONTAL SECTION (E-E)
16" GATE VALVES
AIR VALVE
36" PIPE
36" PIPE
16"x12" NEEDLE VALVE
SECTION A-A
PRESSURE RELIEF VALVE ASSEMBLY
MAIN LINE VALVES
OUTLET FOR RELIEF WATERS
B-B
THROTTLING AND PRESSURE RELIEF VALVES STRUCTURE NEAR STATION 567±
CHICOPEE VALLEY AQUEDUCT
SECTION 3-36 HIGH CONDUIT
PRESSURE RELIEF STRUCTURE

FIG. 8.

secondary station, just upstream from the Nash Hill Reservoir, and provides any added throttling either not made in the primary station near Bondsville for purposes of giving pressures to communities located between the two stations or needed for other reasons inherent with flexible operation of the entire line, under future as well as present conditions.

At the Bondsville Control Structure, the primary station will be operated particularly in the early years, to furnish practically all of the throttling and when, in later years, a greater part of the full aqueduct capacity is needed, the throttling will be used to furnish a differential water pressure at that station capable of operating a water turbine for pumping water to Palmer and Ware, which communities will require a small reservoir at about Elevation 550 for Palmer and 800 for Ware. The foundations of the primary control station are so designed that when Ware and/or Palmer desire water, the control station will form a room in the basement of the future pumping station. A 24-inch valve connection is furnished upstream from the throttling valves and one downstream, so that this future station can be built without interference with flow in the aqueduct (see Figure 9).

The future station provides for a water turbine, operated by head from the Quabbin Reservoir through the aqueduct and discharging into the line to Chicopee. This turbine will run the pumps furnishing the Ware-Palmer supply. Such a station could be used without consuming any power from an electrical auxiliary supply until such time as consumption from Chicopee and other communities downstream from this station reaches about 15 to 18 mgd, which time might be considerably in the future.

Pressure Reliefs and Overflows

The control structure on Belchertown Rd. is equipped with two 9-inch pressure-relief valves and controls with automatic relief control, regulated so that, regardless of whether or not the throttling valves are operated properly, the pressure gradient at this station cannot rise above Elevation 485, because the valves will open, discharging into a nearby brook and preventing such a rise, if the flow in the aqueduct is regulated, or fails to be regulated, in such a manner that the pressure gradient would be above that elevation.

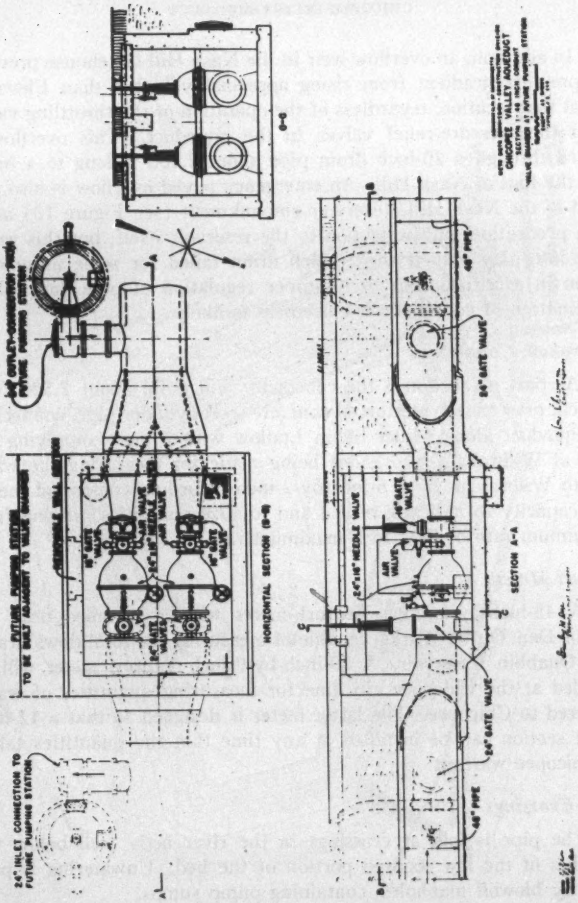

24" INLET CONNECTION TO FUTURE PUMPING STATION
FUTURE PUMPING STATION TO BE BUILT ADJACENT TO VALVE CHAMBER
HORIZONTAL SECTION (B-B)
24" GATE VALVE
48" PIPE
SECTION A-A
CHICOPEE VALLEY AQUEDUCT

FIG. 9.

In addition, an overflow weir in the Nash Hill Gatehouse prevents the pressure gradient from rising appreciably higher than Elevation 425 at that location, regardless of the operation of the throttling valves or of the pressure-relief valves in the aqueduct. This overflow is carried through a 20-inch drain pipe about 2,100 ft long to a brook near the foot of Nash Hill. An emergency paved overflow is also provided in the Nash Hill Reservoir embankment (see Figure 10) as an extra precaution and protection to the reservoir itself, but this would come into play only if the 20-inch drain failed for some unforeseen reason in a critical time of improper regulation of pipe flow, which combination of conditions is extremely unlikely.

Wilbraham Connection

As part of Section 3 the contractor will build about 2,500 ft of 16-inch, prestressed, reinforced-concrete steel-cylinder pipe, connecting the aqueduct along Miller St. in Ludlow with a main supplying the town of Wilbraham, provisions being made for measuring the water sent to Wilbraham by a 6-inch-by-2-inch recording compound meter, with capacity to indicate, record and totalize quantities ranging from a minimum rate of 0.02 to a maximum rate of 1.30 mgd.

Venturi Meters

A 48-inch-by-16-inch Venturi meter will be installed near the Winsor Dam Outlet Works, capable of measuring the total flows drawn from Quabbin Reservoir. A 20-inch-by-9-inch Venturi meter will be installed at the Chicopee city line for measuring quantities of water delivered to Chicopee. The latter meter is designed so that a 12-inch throat section can be installed at any time that the quantities taken by Chicopee warrant.

River Crossings

The pipe is laid at crossings in the river beds, well below the elevation of the low scoured portion of the bed. Unwatering is provided by blowoff manholes, containing pump sumps.

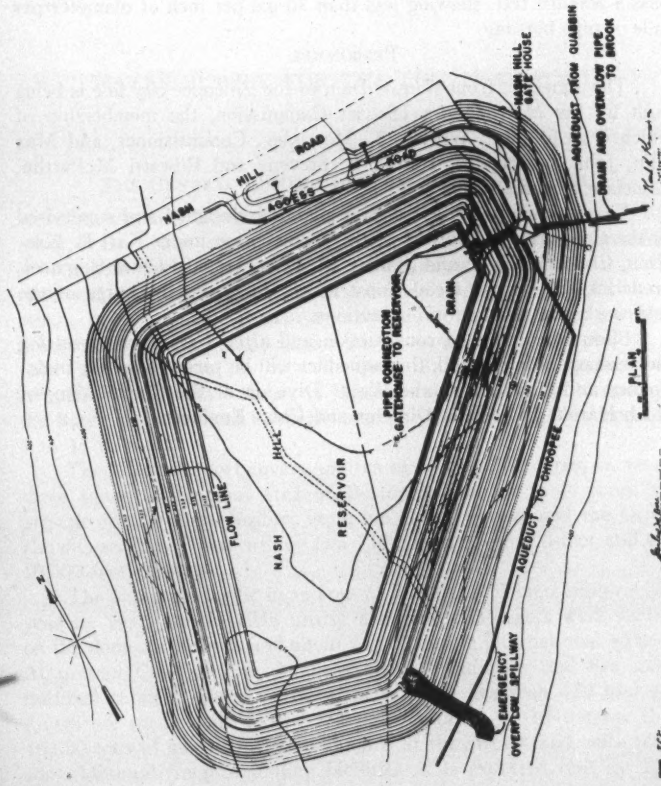

NASH HILL ACCESS ROAD
ROAD
NASH HILL GATE HOUSE
AQUEDUCT FROM QUABBIN
DRAIN AND OVERFLOW PIPE TO BROOK
PIPE CONNECTION GATEHOUSE TO RESERVOIR
DRAIN
NASH HILL
RESERVOIR
FLOW LINE
EMERGENCY OVERFLOW SPILLWAY
AQUEDUCT TO CHICOPEE
PLAN

FIG. 10.

Leakage Requirement

The finished pipe is required to be tested under a hydrostatic head of Elevation 590 for Section 1; of Elevation 560 for Sections 2 and 3; and of Elevation 425 for Section 4. It is also required to pass a leakage test, showing less than 50 gal per inch of diameter per mile of pipe per day.

Personnel

The aqueduct from Winsor Dam to the Chicopee city line is being built by the Metropolitan District Commission, the membership of which is as follows: William T. Morrissey, Commissioner, and Max Ulin, John J. Grigalus, Harold E. Stevens and Edward McPartlin, Associate Commissioners.

Construction of these works is planned, designed and supervised by the Construction Division of this Commission under Karl R. Kennison, Chief Engineer, and Stanley M. Dore, Deputy Chief Engineer. Frederick W. Gow is Head Construction Engineer, in charge of the field work and contractors' operations.

Upon completion of construction and after a satisfactory testing and trial operating period, this aqueduct will be turned over for maintenance and operation to the Water Division of the Commission, of which Harold J. Toole is Director and Chief Engineer.

WATER SUPPLY FOR THE LOGAN AIRPORT

BY GEORGE W. COFFIN*

[*Read June 29, 1949.*]

The General Edward Lawrence Logan Airport

The General Edward Lawrence Logan Airport, to give it its full name, or the Logan International Airport, its more popular designation, is one of the major airports of the world and, when completed, it will rank with the world's finest. In at least one respect it will outrank all others, by virtue of being nearer to the center of a great metropolitan area than any other large airport in the world. By automobile it is only 3.1 miles from the new Terminal Building (now under construction) to the State House in Boston and it is possible to go from the hotel, shopping and financial centers of the city to the airport in 5 to 15 minutes.

The Logan Airport covers an area of about 2,000 acres, or nearly three times the original area of Boston and about three times the present area of East Boston, exclusive of the airport and the Orient Heights section. There will be two 7,000-foot, two 8,000-foot and two 10,000-foot runways.

The passenger traffic in and out of the airport is increasing rapidly year by year, and in 1948 nearly a million passengers were carried on the domestic airlines and about 15,000 on the international airlines. At present there are six domestic airline companies and five international carriers operating from the airport. Between 350 and 400 flights are made daily to and from the airport. In 1948 more than 10,000 tons of air freight were handled at the airport and, with plans for additional freight-handling facilities, it is expected that by 1952 over 100,000 tons will be handled.

The Logan Airport has a value at present of about $60,000,000 and it is estimated that the ultimate development will be in excess of $100,000,000, including about $31,000,000 worth of structures. At

*President, Coffin & Richardson, Inc., Consulting Engineers, 68 Devonshire St., Boston 9, Mass.

any one time there are between $20,000,000 and $30,000,000 worth of planes at the airport, including those about to land or take off.

Available Water Supply

The development of a water system for a major airport is comparable in magnitude to the development of a water supply for a large city. The occupational fire hazards at an airport are the controlling factors in determining the amount of water that must be provided and, in general, the domestic consumption is small compared with the fire-flow demand.

It is frequently asked why sea-water is not used for the fire supply of facilities located on tidewater. Such a supply appears to be a simple solution to the problem of furnishing an unfailing and unlimited supply with relatively short supply mains. Of the several such supplies along the New England coast, the writer knows of four salt-water systems that have been abandoned: the high-pressure fire system in Boston; the fire-supply mains at the Navy Fuel Depot, East Boston; the fire-supply mains at the Navy Shipyard in Hingham, and the fire-supply mains at the Quonset Point Naval Air Station, Rhode Island. The latter three installations were converted to fresh-water systems, but in Boston the mains were entirely abandoned.

The principal reasons for the abandonment of these salt-water systems were that the suction intakes foul up very rapidly with marine growths; the mains, valves and fittings rust and corrode more rapidly, and, in the case of Boston, it was found that in many instances the salt water did more damage to the merchandise and equipment in buildings than the fire itself.

With sea water eliminated as a possible supply, the only other source available is the Boston Metropolitan System.

Fig. 1 shows the principal supply mains of the distribution system in the Metropolitan area and the location of the proposed future pressure tunnel. The only two connections from the Metropolitan System to East Boston are located at the Chelsea Creek bridge and at Brooks St. With these two connections it seemed at first to be a simple problem to supply the airport with all the water that might be required, even up to 15,000 g.p.m. required for deluge sprinkler service in the hangar areas. The problem, however, was not as simple as this and,

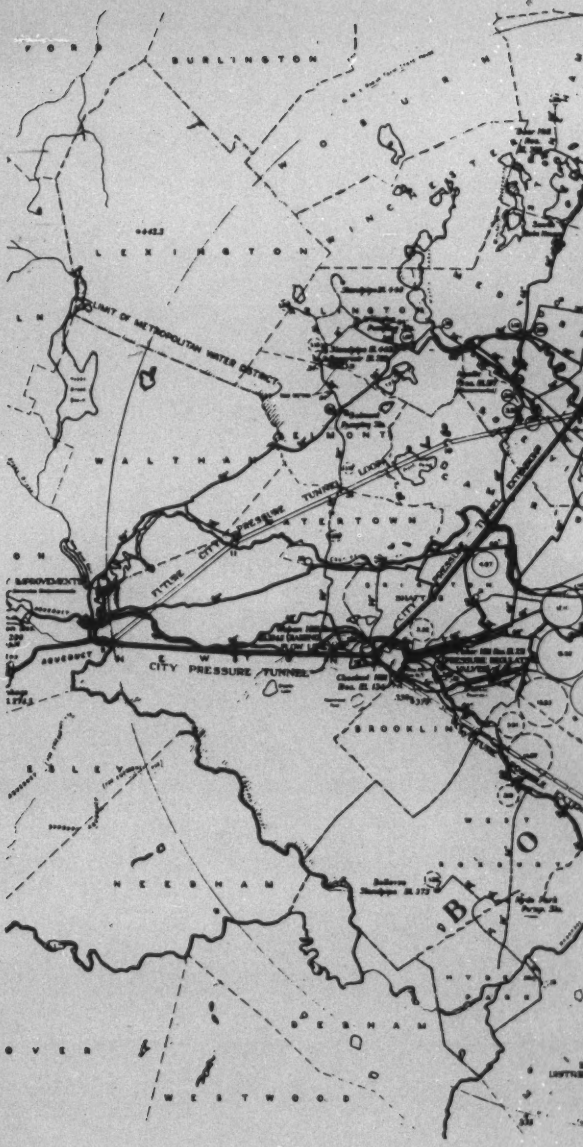

BURLINGTON
LEXINGTON
COUNTY OF METROPOLITAN WATER DISTRICT
WALTHAM
CITY PRESSURE TUNNEL
BROOKLINE
NEEDHAM
DEDHAM
WESTWOOD

FIG.

FIG. 1.

Courtesy of Karl R. Kennison, Chief Engineer
Metr. Distr. Water Supply Commission

in spite of the ample supply from Quabbin Reservoir through the recently constructed pressure aqueducts, it would be impracticable to draw any such quantity of water through either of these connections.

A draft of this magnitude would lower the hydraulic gradient over a large area and the Metropolitan District Commission set 3,000 g.p.m. as the maximum rate at which water should be drawn from the Metropolitan supply, until such time as the system has been reinforced by the proposed pressure tunnel and additional supply mains.

Fig. 2 shows the general layout of the ultimate development of the airport, and the location of the proposed 36-inch connection to the Metropolitan system at Chelsea Creek and the 24-inch connection to the Boston distribution system at Porter St. These connections will be described in detail later.

Water-Supply Requirements and Basis for Design

Flow

Ultimately there will be some 24 large hangars at the airport, with a total ground-floor area of about 24 acres. In addition to the hangars there will be many service buildings and other structures requiring fire protection. Fire underwriters' recommendations provide that these hangars shall have open-head deluge sprinkler systems, which require 5,000 to 7,000 g.p.m. per hangar, the quantity depending on the size of the hangar and other factors. Due to the proposed spacing of hangars and the occupational fire hazard, it was assumed that two such hangars might be on fire at the same time. In addition to the automatic deluge sprinklers, the fire department will require water from hydrants to fight a fire with hose streams from outside the building. To be certain that there will be ample water for such fires, a total fire-flow demand of 15,000 g.p.m. for a one-hour fire, as recommended by the New England Fire Insurance Rating Association engineers, was adopted as the basis of design.

A freighter fire at the dock in Charlestown, Mass., March 10, 1937, required a flow of 35,000 g.p.m. The fire on October 15, 1948, which destroyed the Engine Overhaul and Repair Building at the Quonset Point Naval Air Station, required water probably in excess of 10,000 g.p.m. (See Fig. 15).

For fire service in the sprinklered Terminal Building Area,

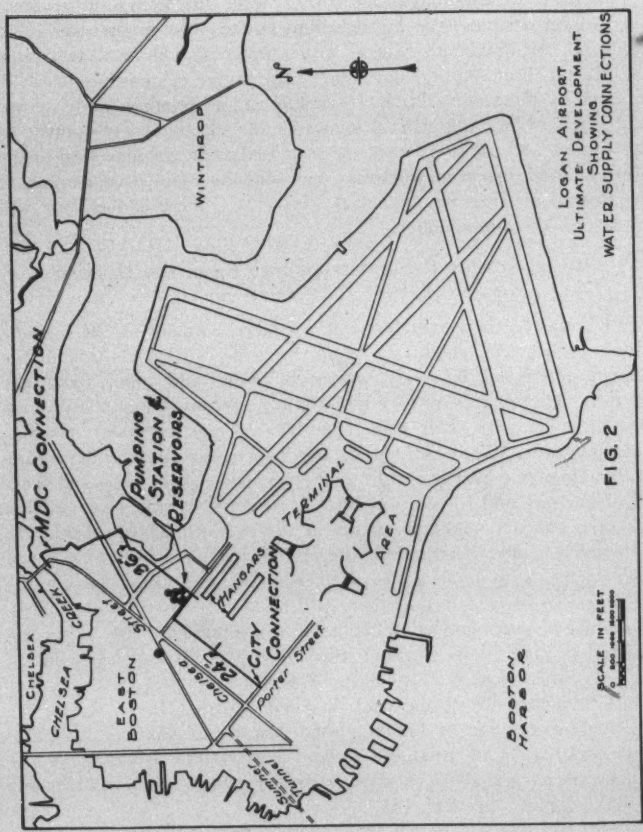

LOGAN AIRPORT
ULTIMATE DEVELOPMENT
SHOWING
WATER SUPPLY CONNECTIONS
WINTHROP
MDC CONNECTION
PUMPING STATION & RESERVOIRS
36"
24"
CITY CONNECTION
HANGARS
TERMINAL
AREA
CHELSEA
CHELSEA CREEK
EAST BOSTON
Chelsea Street
Porter Street
Sumner Tunnel
BOSTON HARBOR
SCALE IN FEET
0 500 1000 2000 3000

FIG. 2

Thompson and Lichtner, Inc., designers of structures in this area, estimated a fire-flow demand of 3,500 g.p.m. plus 1,000 g.p.m. for domestic requirements.

For domestic service in the hangars and elsewhere, except in the Terminal Building Area, an average daily flow of 500 g.p.m. was assumed.

The total peak demand is summarized as follows:

For fire service in hangar areas	15,000	g.p.m.
For fire service in Terminal Building Area	3,500	"
For domestic service during a fire	1,000	"
Total	19,500	g.p.m.

Pressure

A pressure of 70 lb per sq in. at the points of delivery to the Terminal Building Area (see Fig. 3) during periods of maximum flow was found to be necessary, to provide adequate residual pressures at the various sprinkler connections. Actually the pressure at these points will vary, depending upon the location of the point or points of heavy draft in the hangar areas. Analysis showed that, if the distribution system were designed to provide a 70-lb minimum pressure at these points, all requirements would be met for proper sprinkler operation in the Terminal Building and elsewhere.

The Proposed Water System

The water system for the airport will consist of a 36-inch supply main from the Metropolitan system at Chelsea Creek to Prescott St., a 24-inch secondary supply main from a 24-inch main of the City of Boston in Porter St. to Prescott St., three 750,000-gal steel storage reservoirs, a distribution system and a pumping station.

Metropolitan Connection

The supply main from the Metropolitan system will consist of 4,660 ft of 36-inch, cast-iron cement-lined pipe, carried on piles where necessary, from the 36-inch Metropolitan supply main at the Chelsea Creek Bridge to the pumping station and reservoir area on Prescott St. A 12-inch-by-6-inch standard Venturi meter and recorder will be

located at the connection to the Metropolitan supply. The meter will be located in a by-pass, so that in case of extreme emergency the main valve on the 36-inch line can be opened to deliver the full capacity of the main—20,000 g.p.m.—to the airport. The normal maximum flow of 3,000 g.p.m., permitted by the Metropolitan District Commission, will be controlled by a rate-of-flow controller at the pumping station.

After the ultimate development of the Metropolitan distribution system by the construction of the pressure tunnel and additional supply mains, it will be possible to deliver the required fire flows directly to the airport without the use of the reservoirs, and the 36-inch main was designed to carry these flows. It will be necessary, however, to retain the pumping station in order to maintain the required pressure, as the pressures in the Metropolitan system will not be materially greater than at present, even after the addition of the pressure tunnel.

Porter Street Connection

To provide uninterrupted service in case of failure of the 36-inch Chelsea Creek supply, a 24-inch main has been laid from the 24-inch city main in Porter St., just west of the General Electric plant, to the pumping-station site on Prescott St. This connection can be used as a secondary source of supply, to fill the reservoirs from which the pumps draw water to maintain the required pressure throughout the airport. A 12-inch-by-6-inch Builders-Providence Venturi meter is provided, to measure and record any water taken from the Boston water system.

The 24-inch line from Porter St. to Prescott St. and a 16-inch main from this line to the Terminal Building Area were laid in 1949, under the first of the general contracts for the construction of the airport water system.

Under normal operation, it is expected that the supply will be drawn directly from the Metropolitan system at Chelsea Creek and, under this condition, the northerly half of the 24-inch city connection will be used as part of the airport distribution system (see Fig. 3).

Reservoirs or Tanks

To maintain the required fire flows without drawing more than the specified amount of 3,000 g.p.m. from the Metropolitan system,

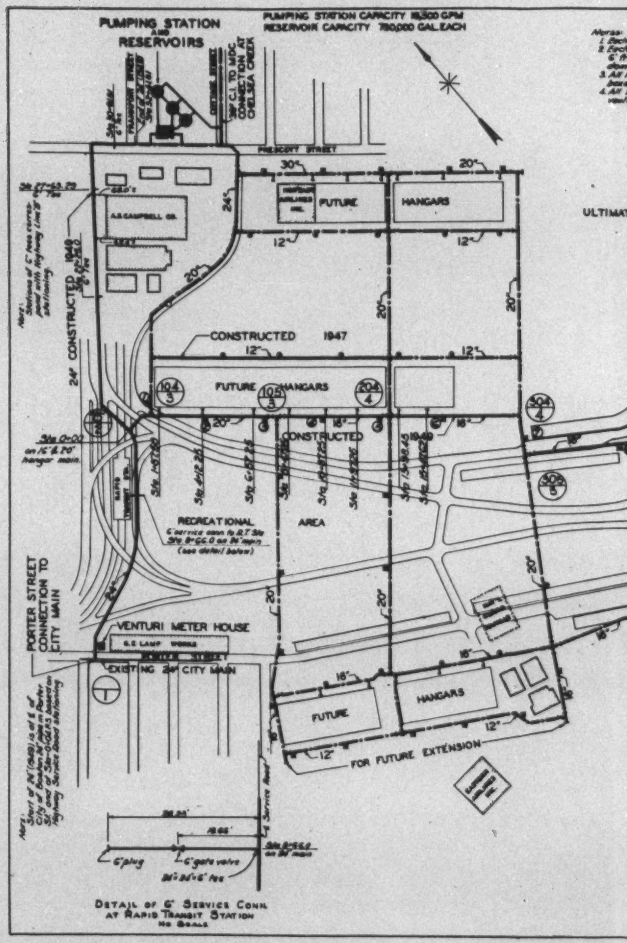
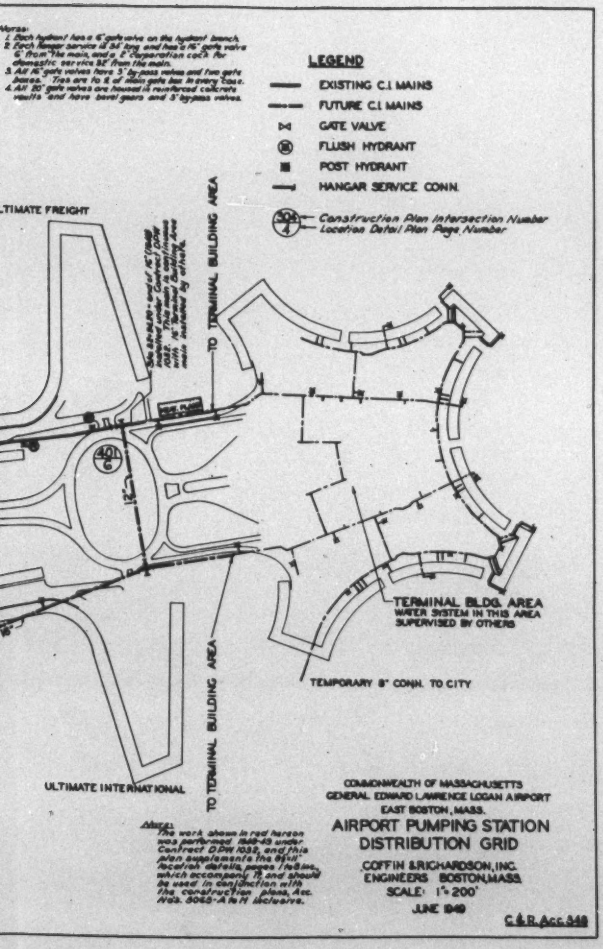

PUMPING STATION AND RESERVOIRS
PUMPING STATION CAPACITY 18,300 GPM
RESERVOIR CAPACITY 750,000 GAL. EACH
PRESCOTT STREET
FUTURE
HANGARS
CONSTRUCTED 1947
RECREATIONAL AREA
PORTER STREET CONNECTION TO CITY MAIN
VENTURI METER HOUSE
EXISTING 24" CITY MAIN
FOR FUTURE EXTENSION
DETAIL OF 6" SERVICE CONN. AT RAPID TRANSIT STATION

FIG. 3.


Notes:
1. Each hydrant has a 6" gate valve on the hydrant branch.
2. Each hangar service is 34" long and has a 16" gate valve 6" from the main, and a 2" corporation cock for domestic service 32" from the main.
3. All 16" gate valves have 3" by-pass valves and two gate boxes. Ties are to ℄ of main gate box in every case.
4. All 20" gate valves are housed in reinforced concrete vaults and have bevel gears and 3" by-pass valves.
LEGEND
EXISTING C.I. MAINS
FUTURE C.I. MAINS
GATE VALVE
FLUSH HYDRANT
POST HYDRANT
HANGAR SERVICE CONN.
Construction Plan Intersection Number
Location Detail Plan Page Number
ULTIMATE FREIGHT
TO TERMINAL BUILDING AREA
TERMINAL BLDG. AREA
WATER SYSTEM IN THIS AREA SUPERVISED BY OTHERS
TEMPORARY 8" CONN. TO CITY
ULTIMATE INTERNATIONAL
TO TERMINAL BUILDING AREA
Notes:
The work shown in red hereon was performed 1948-49 under Contract DPW 1032, and this plan supplements the 8½"x11" location details, pages 1 to 8 inc., which accompany it, and should be used in conjunction with the construction plans, Acc. No's. 5065-A to H inclusive.
COMMONWEALTH OF MASSACHUSETTS
GENERAL EDWARD LAWRENCE LOGAN AIRPORT
EAST BOSTON, MASS.
AIRPORT PUMPING STATION
DISTRIBUTION GRID
COFFIN & RICHARDSON, INC.
ENGINEERS BOSTON, MASS.
SCALE: 1" = 200'
JUNE 1949
C.&R. Acc. 548

. 3.

three 750,000-gal steel-tank reservoirs will be located adjacent to the pumping station. Provision is also made for the future installation of a fourth reservoir, making a total available capacity at this point of 3 mil gal. The reservoirs will be set about a foot above grade, and will have a height of 35 ft and a diameter of 60 ft.

Consideration was given to the use of elevated storage for fire service as being the simplest and most economical means of maintaining the required pressures and fire flows. Studies in conjunction with the aeronautics authorities showed that tanks of sufficient elevation might interfere with the approach zones.

Distribution System

Fig. 3 shows the general plan of the distribution system and the location of the pumping station and reservoirs. The hangar distribution system will consist of 6-inch, 12-inch, 16-inch, 24-inch and 30-inch, Class 150, centrifugally spun cast-iron pipe. All pipe will be cement-lined. The grid is arranged so that the Terminal Building Area and the hangars will receive water from at least two directions. The backbone of the grid system consists of three 20-inch mains running North and South. Sizes of the cross connections were chosen so as to provide full fire flow without excessive pressure losses, even though one of the three main 20-inch lines is out of service.

Valves have been located so as to isolate any break with a minimum interference with the rest of the grid system. All valves 16-inch and greater will be equipped with standard bypass valves. All valves 20-inch and larger will be geared and installed in concrete valve vaults. Valves will be of the A.W.W.A. Standard pattern and open to the right or clockwise.

The hydrants in the hangar aprons will be of the flush type and others throughout the area of the post type, with two standard 2½-inch hose connections and one 4½-inch pumper connection. Sixteen-inch branches are provided for sprinkler connections to all the hangar sites.

Sizes of the various mains in the grid were chosen as the result of several Hardy Cross analyses and are designed to give maximum flow with minimum head losses to all vital parts of the system. Provision was also made for extension of the distribution system southerly, to

care for additional hangars in this area in the future, and the mains have been sized to care for this situation. The distribution system contains 26,000 linear feet of pipe.

Pumping Station

Fig. 4 portrays the architect's conception of the completed pumping station. The building will be of fire-resistant steel-frame construction, with brick walls and a reinforced-concrete substructure and roof. The building consists of a two-story pump room and a single-story office, transformer room and garage wing, and will be founded on Gow-type caisson piles. The pump room is 88 ft by 42 ft in plan and 32 ft high. The utility wing is 88 ft by 22 ft and 13 ft high.

Fig. 5 shows a composite floor and piping plan and Figures 6 and 7 show a cross-section and a longitudinal section, respectively.

Pumping Equipment

For domestic service, four, electric-motor-driven, vertical-shaft turbine pumps with capacities of 250, 500, 750 and 1,000 g.p.m. are provided. These pumps are designed to operate under a positive suction head varying from 36 ft to 1 ft, depending upon the elevation of water in the reservoirs. The discharge head varies from 195 ft to 179 ft, depending upon the suction level and the number of pumps running. The pumps will be operated by 15-hp, 20-hp, 30-hp, and 50-hp motors, respectively, and will have a combined capacity of 2,650 g.p.m. when the tanks are full. Thus, with a supply at the rate of 3,000 g.p.m. available from the Metropolitan connection, the storage reservoirs will not be drawn down for domestic consumption and a full 2.25 mil gal will be available for fire flows.

For fire service, five, electric-motor-driven, vertical-shaft turbine pumps and two centrifugal pumps with dual electric-gasoline-engine drive are provided. The turbine pumps have a rated capacity of 2,600 g.p.m. each at 202 ft dynamic head and are powered by 200-hp motors. The centrifugal pumps are rated at 3,200 g.p.m. each against a dynamic head of 202 ft and are also powered by 200-hp electric motors. The gasoline engines for these pumps are rated at 270 hp. A third 3,200-g.p.m. centrifugal pump, driven by a gasoline engine only, serves as a spare. Space is also provided for a fourth centrifugal pump. The fire pumps operate under the same suction head as the domestic pumps

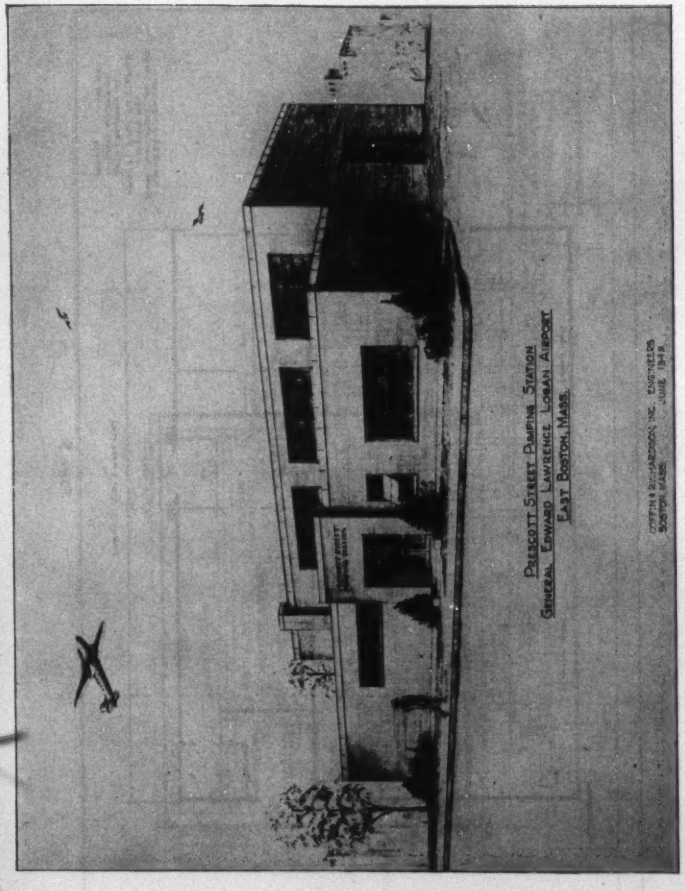

PRESCOTT STREET PUMPING STATION
GENERAL EDWARD LAWRENCE LOGAN AIRPORT
EAST BOSTON, MASS.
COFFIN & RICHARDSON INC. ENGINEERS
BOSTON, MASS. JUNE 1948.

FIG. 4.

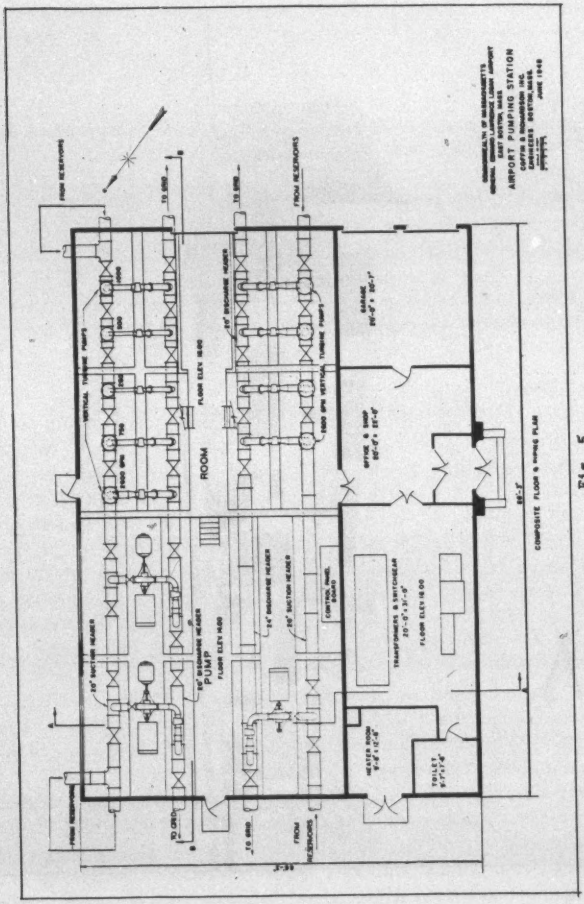

COMMONWEALTH OF MASSACHUSETTS
GENERAL EMPLOYMENT LAWRENCE LOGAN AIRPORT
EAST BOSTON, MASS.
AIRPORT PUMPING STATION
COFFIN & RICHARDSON INC.
ENGINEERS BOSTON, MASS.
JUNE 1948
FROM RESERVOIRS
TO GRID
VERTICAL TURBINE PUMPS
ROOM
FLOOR ELEV 18.00
20" DISCHARGE HEADER
GARAGE
OFFICE & SHOP
20" SUCTION HEADER
PUMP
FLOOR ELEV 14.00
24" DISCHARGE HEADER
CONTROL PANEL BOARD
TRANSFORMERS & SWITCHGEAR
FLOOR ELEV 18.00
HEATER ROOM
TOILET
COMPOSITE FLOOR & PIPING PLAN

Fig. 5

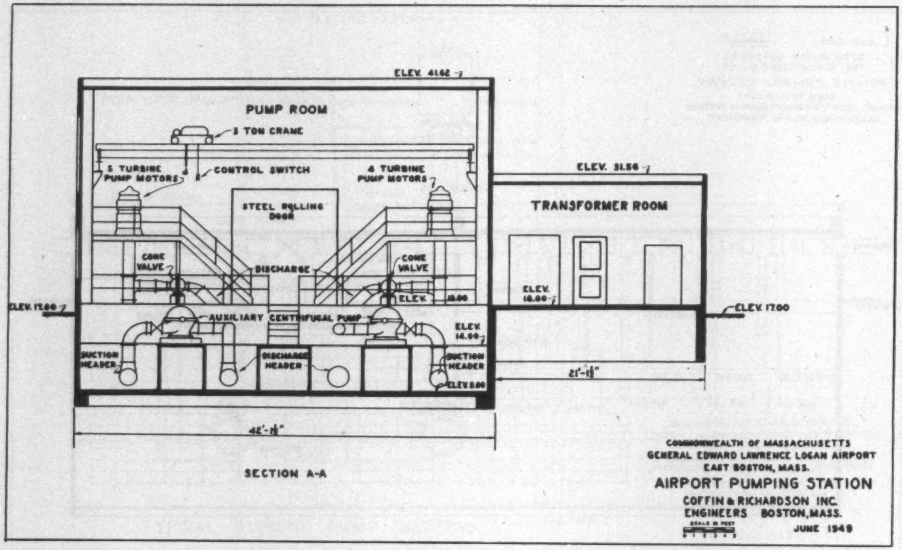

ELEV. 41.62
PUMP ROOM
3 TON CRANE
5 TURBINE PUMP MOTORS
CONTROL SWITCH
4 TURBINE PUMP MOTORS
STEEL ROLLING DOOR
ELEV. 31.56
TRANSFORMER ROOM
CONE VALVE
DISCHARGE
CONE VALVE
ELEV. 18.00
ELEV. 18.00
ELEV. 17.00
ELEV. 17.00
AUXILIARY CENTRIFUGAL PUMP
ELEV. 16.00
SUCTION HEADER
DISCHARGE HEADER
SUCTION HEADER
ELEV. 0.00
22'-11"
42'-11"
SECTION A-A
COMMONWEALTH OF MASSACHUSETTS
GENERAL EDWARD LAWRENCE LOGAN AIRPORT
EAST BOSTON, MASS.
AIRPORT PUMPING STATION
COFFIN & RICHARDSON INC.
ENGINEERS BOSTON, MASS.
JUNE 1949

FIG. 6.

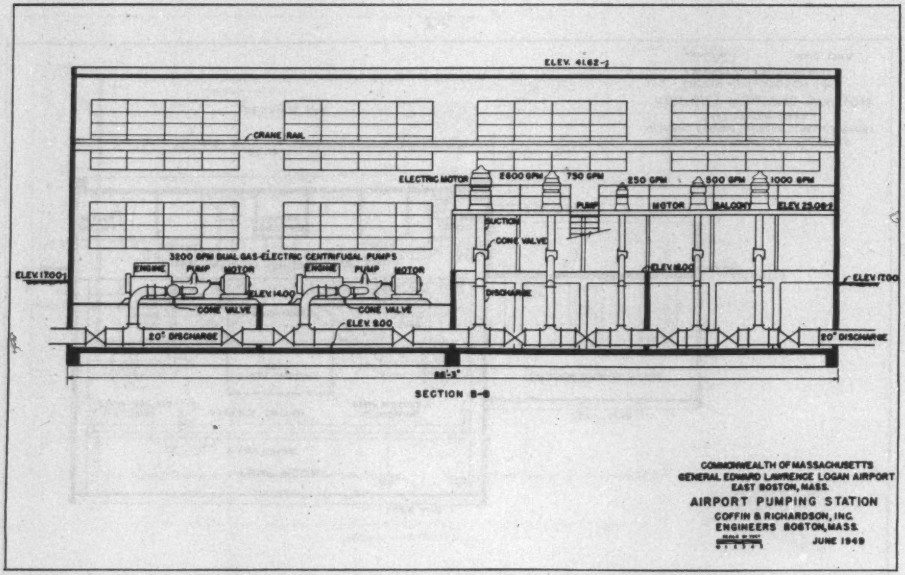
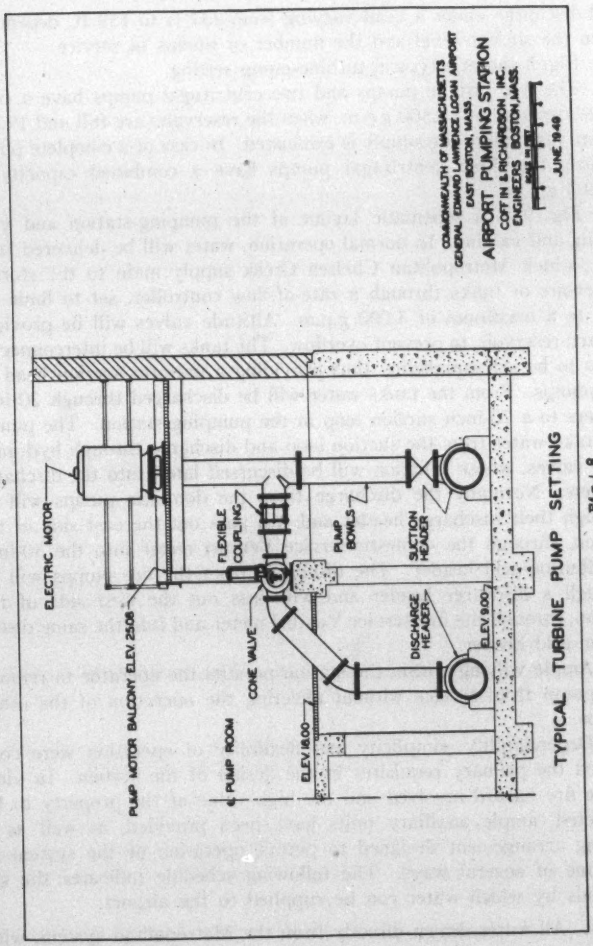

ELEV. 4162-J
CRANE RAIL
ELECTRIC MOTOR
2600 GPM
750 GPM
250 GPM
500 GPM
1000 GPM
PUMP
MOTOR
BALCONY
ELEV. 25.08-J
SUCTION
CONE VALVE
3200 GPM DUAL GAS-ELECTRIC CENTRIFUGAL PUMPS
ENGINE
PUMP
MOTOR
ELEV. (700)
ELEV. 14.00
ELEV. 8.00
DISCHARGE
20" DISCHARGE
88'-3"
SECTION B-B
COMMONWEALTH OF MASSACHUSETTS
GENERAL EDWARD LAWRENCE LOGAN AIRPORT
EAST BOSTON, MASS.
AIRPORT PUMPING STATION
COFFIN & RICHARDSON, INC.
ENGINEERS BOSTON, MASS.
JUNE 1949

Fig. 7



TYPICAL TURBINE PUMP SETTING

Fig. 8

and discharge under a head varying from 237 ft to 159 ft, depending upon the suction level and the number of pumps in service.

Fig. 8 shows a typical turbine-pump setting.

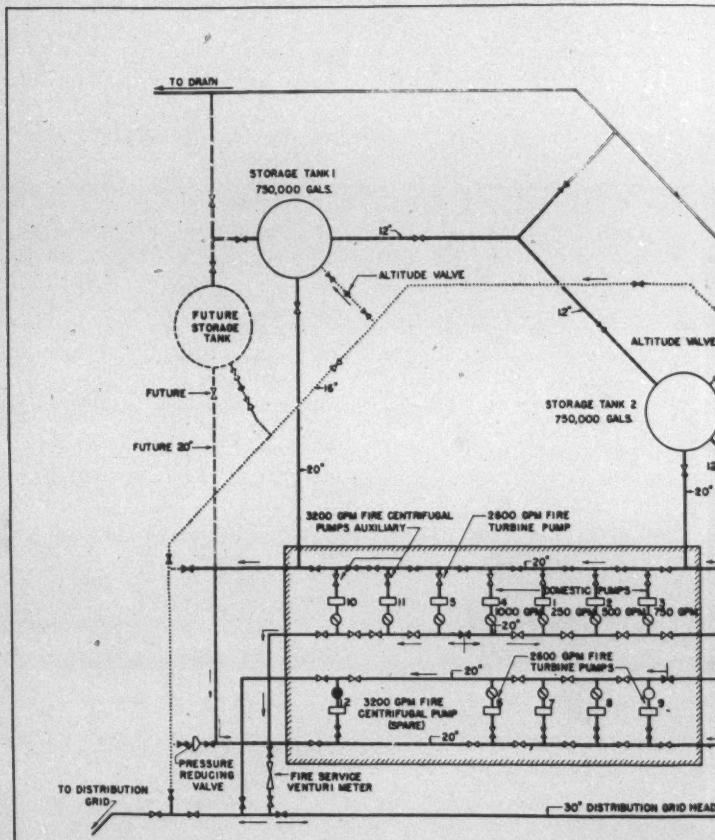
The five turbine pumps and two centrifugal pumps have a combined capacity of 22,500 g.p.m. when the reservoirs are full and 19,500 g.p.m. just before the supply is exhausted. In case of a complete power failure, the three centrifugal pumps have a combined capacity of 12,200 g.p.m.

Fig. 9 is a schematic layout of the pumping-station and yard piping and valving. In normal operation, water will be delivered from the 36-inch Metropolitan Chelsea Creek supply main to the storage reservoirs or tanks through a rate-of-flow controller, set to limit the flow to a maximum of 3,000 g.p.m. Altitude valves will be provided at each reservoir, to prevent overflow. The tanks will be interconnected so as to be self-equalizing, thus providing a uniform suction head on the pumps. From the tanks water will be discharged through 20-inch feeders to a 20-inch suction loop in the pumping station. The pumps will take water from the suction loop and discharge through hydraulic cone valves, whose function will be discussed later, into the discharge headers. Normally the discharge from the domestic pumps will be through their discharge header and will pass out the east side of the station, through the domestic-service Venturi meter into the 30-inch distribution-grid header. The discharge from the fire pumps will be through a discharge header and will pass out the west side of the station, through the fire-service Venturi meter and into the same distribution-grid header.

Ample valving within the station permits the operator to remove any pump from service without affecting the operation of the other pumps.

Dependability, simplicity and flexibility of operation were considered the primary requisites in the design of the system. In view of the fire hazard involved and the high value of the property to be protected, ample auxiliary units have been provided, as well as a valving arrangement designed to permit operation of the system in any one of several ways. The following schedule indicates the six methods by which water can be supplied to the airport:

1. All water drawn directly from the Metropolitan system, with


TO DRAIN
STORAGE TANK 1
750,000 GALS.
12"
ALTITUDE VALVE
FUTURE
STORAGE
TANK
FUTURE
16"
FUTURE 20"
20"
12"
ALTITUDE VALVE
STORAGE TANK 2
750,000 GALS.
12
20"
3200 GPM FIRE CENTRIFUGAL
PUMPS AUXILIARY
2800 GPM FIRE
TURBINE PUMP
20"
DOMESTIC PUMPS
10
11
5
4
1
2
3
1000 GPM
250 GPM
500 GPM
750 GPM
20"
20"
2800 GPM FIRE
TURBINE PUMPS
12
3200 GPM FIRE
CENTRIFUGAL PUMP
(SPARE)
6
7
8
9
20"
PRESSURE
REDUCING
VALVE
FIRE SERVICE
VENTURI METER
TO DISTRIBUTION
GRID
30" DISTRIBUTION GRID HEAD

Fi

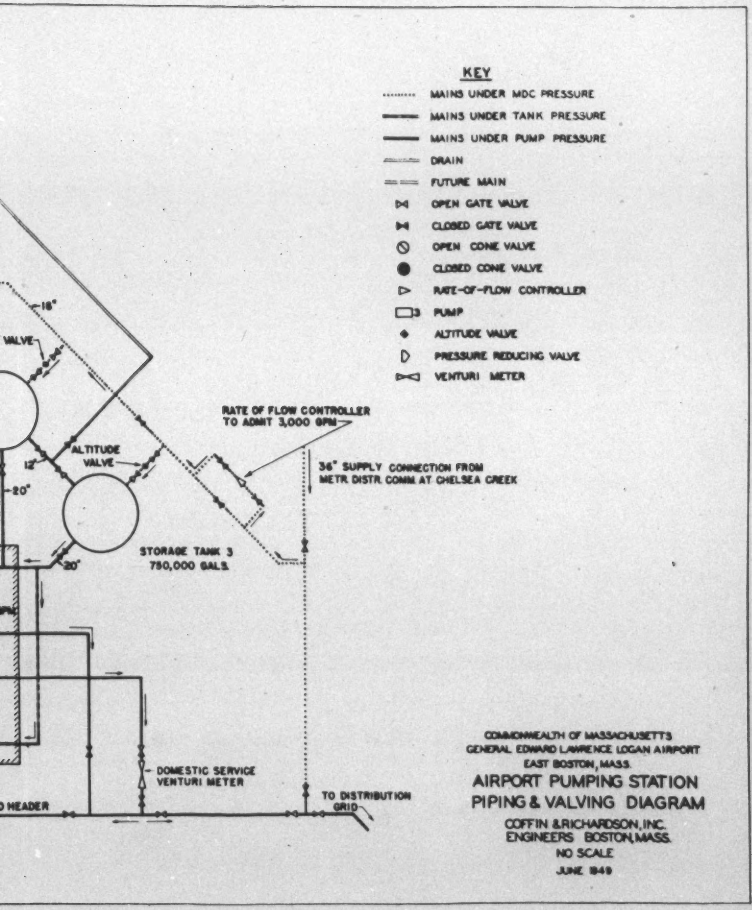

KEY
MAINS UNDER MDC PRESSURE
MAINS UNDER TANK PRESSURE
MAINS UNDER PUMP PRESSURE
DRAIN
FUTURE MAIN
OPEN GATE VALVE
CLOSED GATE VALVE
OPEN CONE VALVE
CLOSED CONE VALVE
RATE-OF-FLOW CONTROLLER
PUMP
ALTITUDE VALVE
PRESSURE REDUCING VALVE
VENTURI METER
18"
VALVE
ALTITUDE VALVE
12"
20"
20"
RATE OF FLOW CONTROLLER TO ADMIT 3,000 GPM
36" SUPPLY CONNECTION FROM METR. DISTR. COMM. AT CHELSEA CREEK
STORAGE TANK 3
750,000 GALS.
DOMESTIC SERVICE VENTURI METER
TO DISTRIBUTION GRID
COMMONWEALTH OF MASSACHUSETTS
GENERAL EDWARD LAWRENCE LOGAN AIRPORT
EAST BOSTON, MASS.
AIRPORT PUMPING STATION
PIPING & VALVING DIAGRAM
COFFIN & RICHARDSON, INC.
ENGINEERS BOSTON, MASS.
NO SCALE
JUNE 1949

FIG. 9.

the city supply shut off—tanks and pumping station in operation.

2. All water drawn from the city supply, with the Metropolitan system shut off—tanks and pumping station in operation.
3. All water drawn directly from the Metropolitan supply, with the city supply shut off—tanks by-passed and pressure maintained by the pumps.
4. All water drawn from the city supply with the Metropolitan supply shut off—tanks by-passed and pressure maintained by the pumps.

   [The quantity available for the airport in cases 3 and 4 is limited to 3,000 g.p.m., except that, in case of a conflagration, the 36-inch valve at Chelsea Creek can be opened to give the maximum flow that the Metropolitan system can furnish.]
5. All water from the Metropolitan supply—tanks and pumping station by-passed.
6. All water from the city supply—tanks and pumping station by-passed.

   [In cases 5 and 6, the quantity and pressure available at the airport will be entirely dependent upon the demand and pressure in the Metropolitan and city systems throughout the low-pressure areas and, under conditions of heavy draft within the Metropolitan system, there will be but little water and very low pressures available for the airport.

Pump Controls

With a total of twelve pumps and the requirement of a minimum pressure of 70 lb per sq in. at the Terminal Building Area during periods of peak demand, studies showed that a system of pressure controls alone, to operate the pumping station automatically, would not be feasible. In a closed system of this magnitude with no storage on the distribution system, pressure controls, even at numerous points in the system, would not truly indicate the required discharge of the station.

The problem was solved by means of a pressure-flow control system, which was developed in coöperation with Builders-Providence, Inc., of Providence, R. I. Fig. 10 contains a diagrammatic sketch of

the control system, and also shows the combined head-capacity curves for the pumps.

As previously stated, the four domestic pumps discharge through a domestic-service Venturi meter and the fire pumps discharge through a fire-service Venturi meter. These Venturis measure the flow from their respective pumps and automatically bring more pumps into service or put pumps out of service in accordance with the demand.

The control system is arranged so that the smallest domestic pump, with a capacity of 250 g.p.m., will operate continuously, satisfying all demands within its capacity and maintaining pressure in the system at low flows. When the flow increases to 250 g.p.m., a switch in the control cabinet, operated by the domestic flow meter, will start the 500-g.p.m. pump. If the flow continues to increase and reaches 750 g.p.m., a second control switch will start the 750-g.p.m. pump. If the flow decreases instead and drops to 200 g.p.m., the 500-g.p.m. pump will be stopped and the 250-g.p.m. pump will again operate alone. The sequence of operation for all of the pumps in the domestic series is the same as described for these two pumps.

When the combined capacity of the domestic pumps reaches 2,500 g.p.m., the first fire pump will start. This fire pump is started by a switch in the domestic flow-meter control cabinet. After the fire pump has been brought up to speed and is taking care of the system demand, the pressure in the system will have been raised beyond the shut-off head of the domestic pumps, which will then be stopped automatically. Now, with the first fire pump operating and with flow passing through the fire-flow meter, the control-switch cabinet, operated by this meter, will assume control of the fire pumps. As the flow reaches 2,500 g.p.m., the second fire pump will start. At 5,000 g.p.m. the third fire pump will start, and so on, until the system demand is satisfied or all pumps are in operation.

On decreasing flow the fire pumps are shut down in sequence at rates approximately 500 g.p.m. less than the starting point for each pump. As the flow drops to 2,000 g.p.m., the domestic pumps are started in operation as a group and, when all of them are up to speed, the last fire pump is shut down and the demand is again taken over by the domestic-pump group.

In the event that the Venturi recorder fails to actuate the pumps,

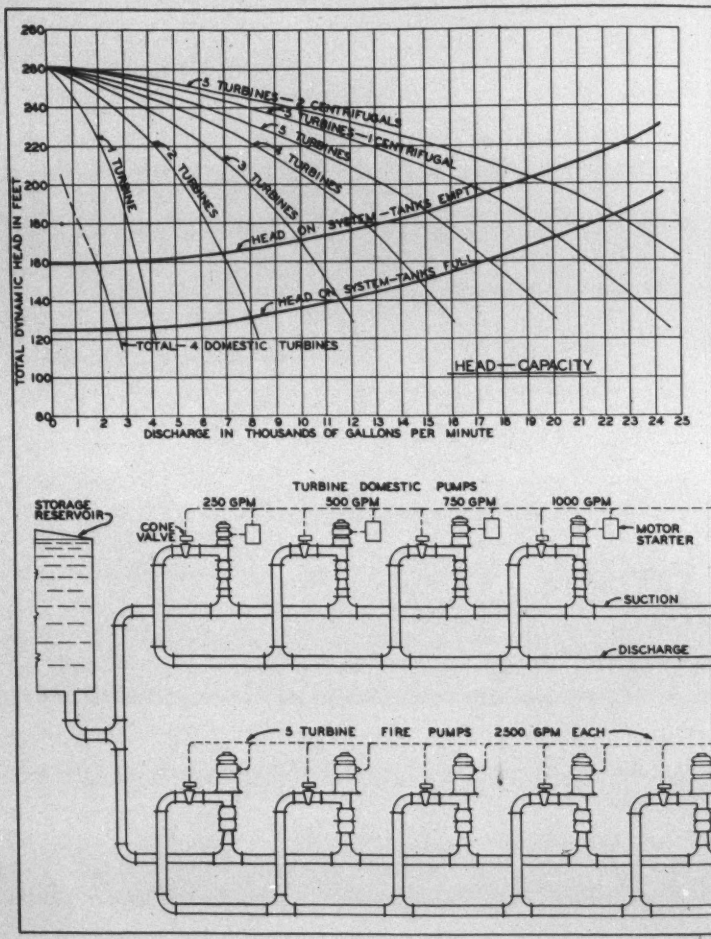
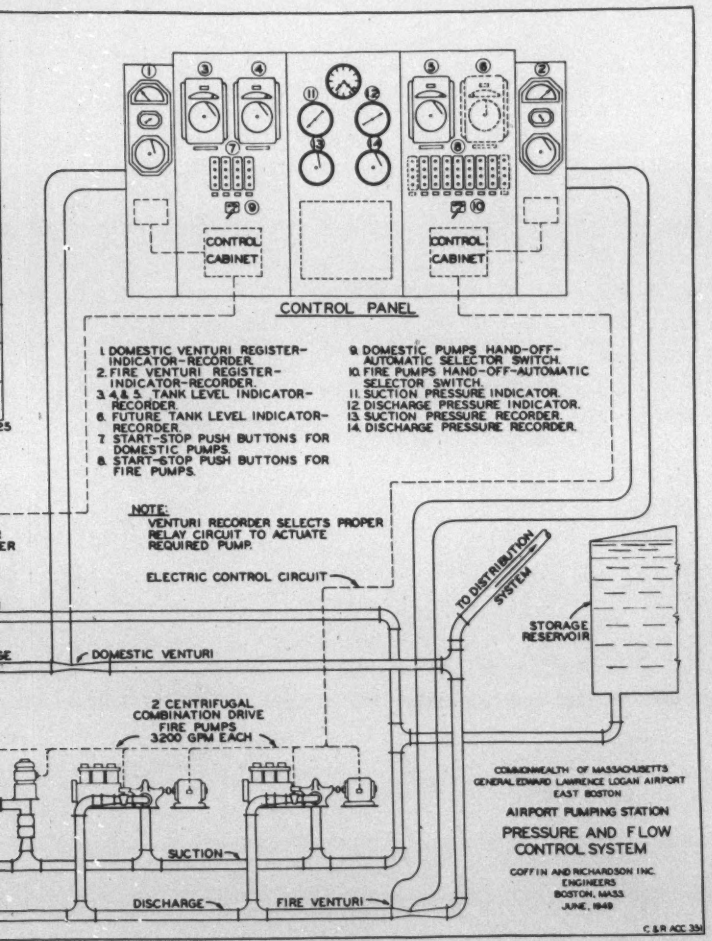

TOTAL DYNAMIC HEAD IN FEET
DISCHARGE IN THOUSANDS OF GALLONS PER MINUTE
5 TURBINES — 2 CENTRIFUGALS
5 TURBINES — 1 CENTRIFUGAL
5 TURBINES
4 TURBINES
3 TURBINES
2 TURBINES
1 TURBINE
HEAD ON SYSTEM — TANKS EMPTY
HEAD ON SYSTEM — TANKS FULL
TOTAL — 4 DOMESTIC TURBINES
HEAD — CAPACITY
STORAGE RESERVOIR
CONE VALVE
TURBINE DOMESTIC PUMPS
250 GPM
500 GPM
750 GPM
1000 GPM
MOTOR STARTER
SUCTION
DISCHARGE
5 TURBINE FIRE PUMPS 2500 GPM EACH

Fig. 10


CONTROL CABINET
CONTROL CABINET
CONTROL PANEL
1. DOMESTIC VENTURI REGISTER-INDICATOR-RECORDER.
2. FIRE VENTURI REGISTER-INDICATOR-RECORDER.
3, 4 & 5. TANK LEVEL INDICATOR-RECORDER.
6. FUTURE TANK LEVEL INDICATOR-RECORDER.
7. START-STOP PUSH BUTTONS FOR DOMESTIC PUMPS.
8. START-STOP PUSH BUTTONS FOR FIRE PUMPS.
9. DOMESTIC PUMPS HAND-OFF-AUTOMATIC SELECTOR SWITCH.
10. FIRE PUMPS HAND-OFF-AUTOMATIC SELECTOR SWITCH.
11. SUCTION PRESSURE INDICATOR.
12. DISCHARGE PRESSURE INDICATOR.
13. SUCTION PRESSURE RECORDER.
14. DISCHARGE PRESSURE RECORDER.
NOTE:
VENTURI RECORDER SELECTS PROPER RELAY CIRCUIT TO ACTUATE REQUIRED PUMP.
ELECTRIC CONTROL CIRCUIT
TO DISTRIBUTION SYSTEM
STORAGE RESERVOIR
DOMESTIC VENTURI
2 CENTRIFUGAL COMBINATION DRIVE FIRE PUMPS 3200 GPM EACH
SUCTION
DISCHARGE
FIRE VENTURI
COMMONWEALTH OF MASSACHUSETTS
GENERAL EDWARD LAWRENCE LOGAN AIRPORT
EAST BOSTON
AIRPORT PUMPING STATION
PRESSURE AND FLOW CONTROL SYSTEM
COFFIN AND RICHARDSON INC.
ENGINEERS
BOSTON, MASS.
JUNE, 1949
C & R ACC 334

a low-pressure switch is included, which also will start the pumps in the event of a sudden drop in the system pressure.

When twelve pumps with a combined capacity of 22,500 g.p.m. are discharging into a closed system, such as at the airport, the elimination of water-hammer and surges, created by 2,600-g.p.m. pumps going on and off, was one of the major problems facing the designer. Hydropneumatic tanks, while often used on smaller installations, are out of the question on an installation of this magnitude, due to their required size.

This problem at Logan Airport was met by specifying that individual cone valves be located on the discharge of each pump. The cone valve acts as a throttle, allowing the pump discharge to increase gradually, so that a large volume of water will not be discharged instantaneously into the system and cause a "slam", with momentary excessive pressures. At Logan Airport, the cone valves operate integrally with the control system. When the flow through a Venturi is such that another pump is needed, the control system starts the pump motor. The pump commences to discharge against a closed cone valve. When a predetermined pressure is reached, the cone valve begins to open, allowing the pump to discharge into the system. The cone valve thus permits the pump to come up to speed and gradually increases the discharge into the system. Should the cone valve fail to open, the pump is cut out and locked out by means of a time-delay circuit.

When the flow through a Venturi tube is such that one pump is to be dropped from service, the control system first causes the cone valve to commence closing. When the cone valve is nearly closed, the pump motor is cut out. Thus, in decreasing flow, the cone valve acts to decrease the discharge into the system slowly.

Electrical Features

The Boston Edison Co. will erect two unit substations at the airport. By means of an interconnection feature, the pumping station can draw power from either of these substations. Thus a failure of one substation will not leave the pumping station without an alternate source of power.

As it is unlikely that both substations will be out of service at the

same time, it is believed that, with three of the pumps equipped with gasoline-engine drive, the airport will be adequately protected. These three pumps have a combined capacity of about 12,200 g.p.m. A fourth gasoline-engine-driven pump can be installed later, if deemed necessary.

Power will be delivered to the station at 4,160 volts and all fire-service pumps will operate at this voltage. Transformers will reduce the current to 440 volts for the domestic-service pumps and auxiliaries, and to 110 volts for the lighting and control circuits. The total rated installed horsepower (electric) for the pumps will be 1,515 hp.

Mechanical Equipment

The entire building will be heated by an oil-fired steam heater with ceiling-suspended unit heaters, located in the transformer and switchgear area, office and garage; wall-mounted cabinet-type heaters in the pump room, and fin-type surface radiators in the toilet.

To remove any gasoline fumes that might collect below the surface of the checkered steel-plate floor from the gasoline engines, a 1,200-cfm unit exhaust blower will be installed. A portable generator will be used to operate the blowers at times of power failure. The transformer and switchgear area will be ventilated by power-controlled roof ventilator and fan units.

A three-ton crane will operate the entire length of the pump room for convenience of handling heavy mechanical equipment.

Status of the Airport Development

More than 29,000 ft of runways have been constructed to date and the first stage of the development of the Terminal Building Area is nearing completion.

Plans and specifications have been prepared for the entire water system. The 24-inch Porter St. connection, extending northerly to the pumping-station area, and a 16-inch branch from this line to the Terminal Building Area were constructed this past spring by C. Reppucci & Sons, Inc., and are now in service. These two lines have a total length of about 7,200 ft.

Cost

The complete water system, as described in this paper, is estimated to cost about $1,750,000, of which $213,000 has been spent (October 1, 1949).

Some Recent Disastrous and Costly Airport Fires

In concluding the description of the Logan Airport water system, the writer makes no apology for the fact that the theme of this paper is a plea for airport fire protection. Too many people have the same idea about fire protection as the lady who wrote to her Congressman as follows:

"Mr. Donald Jackson, Congress:

I am of the opinion that last night's fire would not have caused so much damage if the fire extinguishers had been in order. Why not pass a law that all extinguishers have to be examined ten days before every fire?

Respectfully,
Mrs. Hiram W."

Despite the widespread use and value of the many types of chemical fire extinguishers, water is still the first line of defense in fire fighting and, to be of any value, the pressure must be adequate, the quantity ample and the supply available at all times, ready for instant use.

Records of the National Fire Protection Association show that over a period of more than 20 years fire losses in *unsprinklered* hangars have averaged $309,000 per hangar, as against an average loss of only $2,000 per hangar fire in *sprinklered* hangars—a ratio of loss of 155 to 1.

The following figures illustrate more graphically than words the extravagance of failure to provide airport structures with adequate fire protection.

Amarillo, Texas, Airplane Hangar, September 9, 1948 (Figures 11 and 12)

This was an *unsprinklered hangar* without automatic fire-detection equipment or fire-division walls. The hangar was about 300 ft by 165 ft in plan and 30 ft high, and contained much wooden construction.

The fire was discovered at 2:35 a.m. by a girl working in the Administration Building about one mile away. Fire equipment was forced to travel 10½ miles to the fire, and this fact, plus the delayed

FIG. 11.—AMARILLO, TEXAS, AIRPLANE HANGAR BEING DESTROYED BY FIRE, SEPTEMBER 9, 1943.

FIG. 12.—AMARILLO, TEXAS, AIRPLANE HANGAR BEING DESTROYED BY FIRE, SEPTEMER 9, 1948.

discovery, condemned the hangar itself, but the *firemen were enabled, by having an adequate water supply, to save adjacent structures.* Heat developed to such an extent that the unprotected steel columns and trusses warped and bent like wire, with the result that almost total collapse of the structure occurred. *Loss*: $320,000.

Lincoln, Nebraska, National Guard Hangar, March 3, 1949 (Figures 13 and 14)

This was an *unsprinklered hangar* without automatic fire-protection equipment. It was about 200 ft by 160 ft in plan, with a ceiling 40 ft high. The hangar was constructed of wood sheathing on a steel frame, with composition roof covering on a wood-plank roof deck. Wooden-joist roof supports were fastened to unprotected steel columns, trusses and beams. The water supply was inadequate and, with no sprinkler system, the structure was condemned to total destruction, despite the valiant efforts of the fire department. *Loss*: $500,000.

Quonset Point Naval Air Station, Engine Overhaul and Repair Building, October 15, 1948

Figure 15 is a view of the fire at the Engine Repair and Overhaul Shop of the Quonset Point Naval Air Station, Rhode Island. The first alarm was rung at 3:42 p.m. The second was sent in at 3:45 p.m. and at 4:10 p.m., only 25 minutes later, the roof collapsed, with the subsequent total destruction of the building. The building was *unsprinklered* and contained much wooden construction and substandard fire-division walls. There was an *ample supply of water* at the air station but, due to the rapid spread of the fire, *with no sprinklers available for deluge service,* the building was doomed to destruction very quickly after the start of the fire. The chief effort of the Fire Department was to prevent the spread of the fire to adjacent hangars and other nearby structures. Nearly 2 mil gal of water were used in fighting this fire.

Loss: Building, $500,000; Contents, $1,500,000; Total, $2,000,000.

* * * *

The pictures from which the accompanying figures were made and the data on the fires illustrated were obtained through the cour-

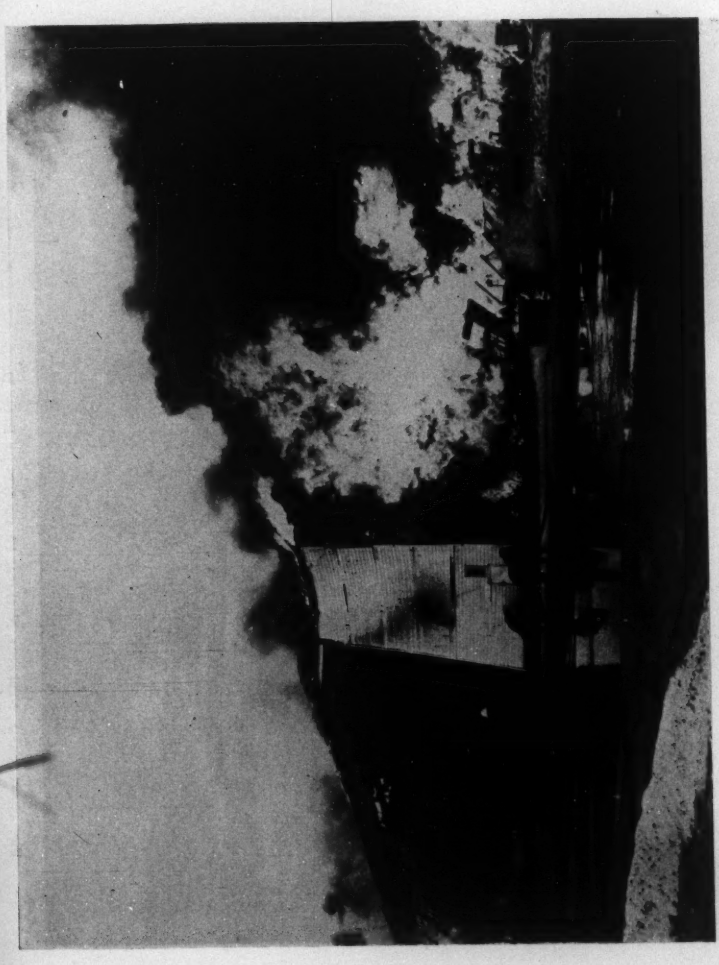


FIG. 13.—LINCOLN, NEBRASKA, NATIONAL GUARD HANGAR BEING DESTROYED BY FIRE, MARCH 3, 1949.

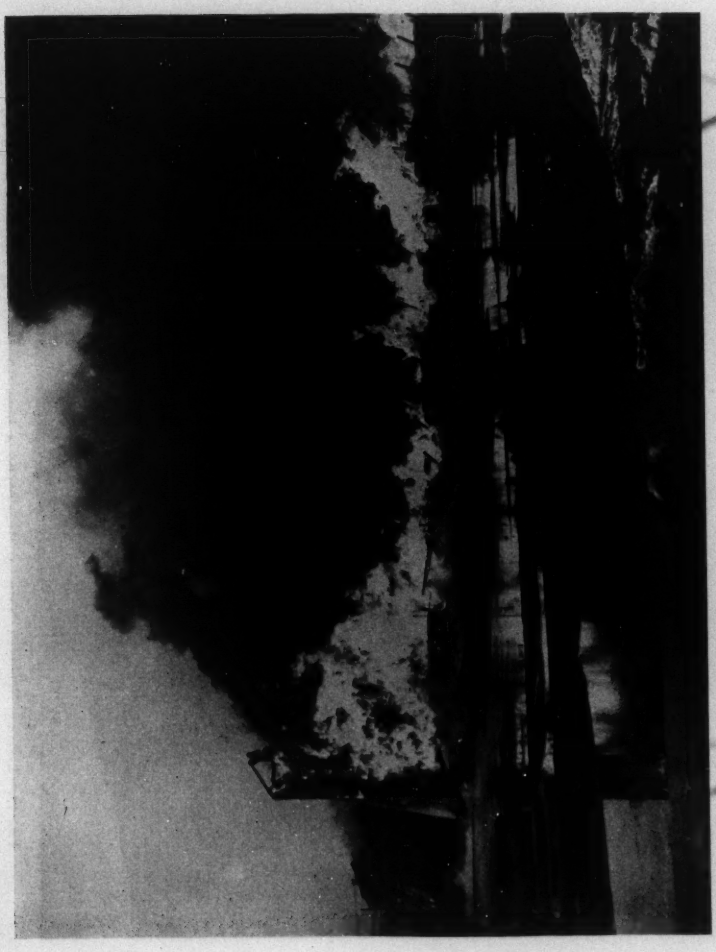


FIG. 14.—LINCOLN, NEBRASKA, NATIONAL GUARD HANGAR BEING DESTROYED BY FIRE, MARCH 3, 1941

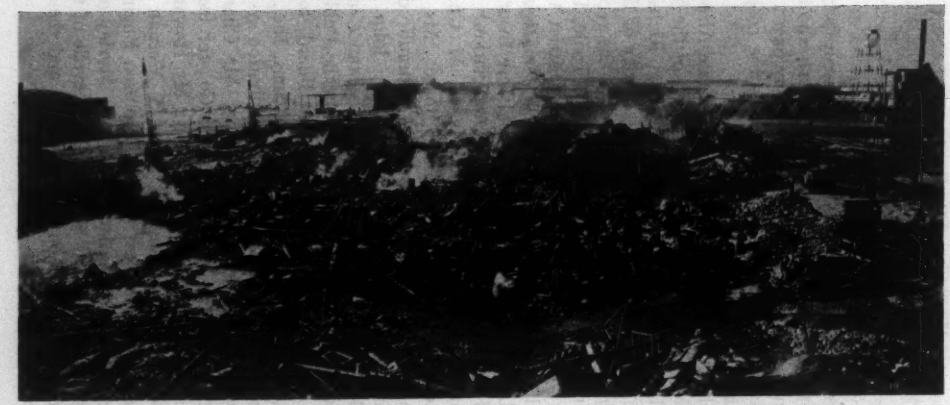


FIG. 15.—QUONSET POINT NAVAL AIR STATION—ENGINE OVERHAUL AND REPAIR BUILDING DESTROYED BY FIRE, OCTOBER 15, 1948.

tesy of Mr. George H. Tryon, III, Secretary of the Committee on Aviation and Airport Fire Protection of the National Fire Protection Association.

ACKNOWLEDGMENTS

The design of the Logan Airport water supply has been a co-operative enterprise and a complete list of all those who have assisted the writer's firm in this design would require many pages. The writer, however, particularly acknowledges with thanks the coöperation and valuable assistance of the following:

Mr. Joseph J. Mulhern, Chairman of the State Airport Management Board; Mr. Miles N. Clair, Vice-President of the Thompson & Lichtner Co., Inc., Consulting Engineers; General Richard K. Hale, Mr. Everett N. Hutchins and Mr. Herbert D. Hurley of the State Department of Public Works, under whose direction the recent development of the airport was begun; Mr. Harold J. Toole, Director and Chief Engineer, Water Division, Metropolitan District Commission; Mr. Daniel Sullivan, Chief Engineer of the Water Division, Boston Public Works Department; The New England Fire Insurance Rating Association and the National Fire Protection Association; Mr. John L. Lymberg, Senior Airport Engineer, and Mr. H. M. Chase, Airport Engineer, of the State Airport Management Board; Mr. H. K. Barrows, Consulting Engineer, who reviewed the hydraulic design; Mr. Charles G. Richardson, Vice-President, and Mr. John R. Hartley, Engineer, Builders-Providence, Inc., for their assistance in developing the pump-control system; Miss L. M. Maloof in the Public Relations Department of the State Airport Management Board, for statistical data relating to the airport; C. Reppucci and Sons, Inc., contractors for the first stage of the development of the distribution system, for the excellent quality of work which they have done; Mr. Charles H. Connors, Field Engineer for the Fairbanks-Morse Co., for technical data used in the selection of the pumping equipment; Mr. Howard A. Mayo, Engineer and Manager, New England Office, S. Morgan Smith Co.; Mr. W. W. Thompson, President of the Thompson Engineering Co., designers of the electric sub-stations; Mr. J. A. Morley of the Pittsburgh-Des Moines Steel Co. and Mr. J. Edgar Revelle of the Chicago Bridge and Iron Co., for data on the reservoirs, and the engineering staff of the General Electric Co.

Acknowledgment is also made of the helpful assistance rendered by the many pipe, pump, valve and equipment manufacturers in furnishing technical data.

Finally, much credit is due the following members of the writer's engineering staff, for their painstaking efforts in developing the detail design: John C. Adams, Stephen E. Dore, James F. Folsom and Karl R. Snow.

ALGAE CONTROL AND METHOD OF ENUMERATION

BY SAMUEL O. SWARTZ*

[*Received August 6, 1949.*]

THE study of the microscopic organisms in water dates back to the seventeenth century. With the invention of the compound microscope, observers began to search ponds and streams for various kinds of microscopic life. It was not until 1850, following the microscopic work by Dr. Hassall of London, that the study of organisms in drinking water was recognized as having a practical sanitary value.

In 1887 the Massachusetts State Board of Health began a systematic examination of all the water supplies of the State. The city of Boston established a biological laboratory at Chestnut Hill Reservoir in 1889 for the purpose of studying microörganisms. The examination and studies of biological characteristics were conducted by George C. Whipple until 1895, when the water supply of Boston came under the control of the Metropolitan Water Works. The laboratory work has continued under supervision of different workers to the present day.

Various methods of microscopical examination were first used, until the Sedgwick and Rafter procedure superseded all others. The method has been modified somewhat, but its essential character has not been changed.

The impounding of water in a reservoir results in environmental changes which produce aquatic microscopic organisms. It is important that water-supply operators have a knowledge of algae, the troubles they may cause and the modern methods of control, as well as to explain the following conditions:

1. taste and odor
2. color, clogging of pipes, screens or filters
3. unusually high chlorine demands and high pH, which may result in poor coagulation.

*Assistant Bacteriologist, Water Division, Metropolitan District Commission, 20 Somerset St., Boston, Mass.

MICROSCOPICAL EXAMINATION OF WATER

Sample from
Date of Collection.
Date of Examination.

Depth of Sample.
Collector.
Examiner.

Grade of Surface.
Temperature.
Concentration.

NO. OF SQUARES EXAMINED	1	2	3	4	5	6	7	8	9	10	Total	No. per c. c.	Standard units per c. c.
DIATOMACEÆ													
Asterionella 5	18	16	12	6	20	10	4			8	94	188	940
Cocconeis 5													
Cyclotella 5			1						7		28	4	2
Cymbella 5													
Diatoma 3													
Eunotia													
Fragilaria 2.5													
Gomphonema													
Melosira					10						10	20	20
Meridion													
Navicula 5										1	1	2	6
Nitzschia 15		1									1	2	3
Pleurosigma													
Stephanodiscus	1		1		1			1		1	5	10	10
Surirella													
Synedra 2/5	5		10		25	6		30		15	91	182	78
Tabellaria 1/2	4		3		13		10		20		54	108	95
CHLOROPHYCEÆ													
Ankistrodesmus													
Botryococcus			3						2		5	10	10
Closterium													
Coelastrum 6								10			16	32	32
Cosmarium													
Desmidium													
Dictyosphærium													
Eudorina													
Genium													
Pandorina													
Pediastrum													
Protococcus													
Scenedesmus													
Sphærozosma													
Spirogyra													
Staurastrum													
Ulothrix													
Volvox													
Zoospores													
CYANOPHYCEÆ													
Anabæna													
Aphanizomenon													
Chroococcus													
Calbronema													
Coleosphærium													
Gloeocapsa													
Lyngbia													
Merismopedia													
Microcystis													
Oscillaria													
SCHIZOMYCETES AND FUNGI													
Crenothrix													
Leptothrix													
Sphærotilus													
Zoogloea													

All organisms are enumerated by the areal measurement. Filaments and spheres are counted as one unit. The Whipple micrometer shown on this sheet has been enlarged to demonstrate the method used in counting algae. The approximate values shown on this chart were estimated by G. C. Whipple.

N= number of squares counted
T= total number of organisms found in all squares counted
V= number of cubic centimeters of samples filtered
C= number of cubic centimeters of water used in washing the samples
S= number of millimeters of slice

$$N = \frac{T}{10} \times \frac{\frac{S}{250} \times \frac{C}{5 c.c.}}{\frac{1000}{c.c.}} = 2T$$

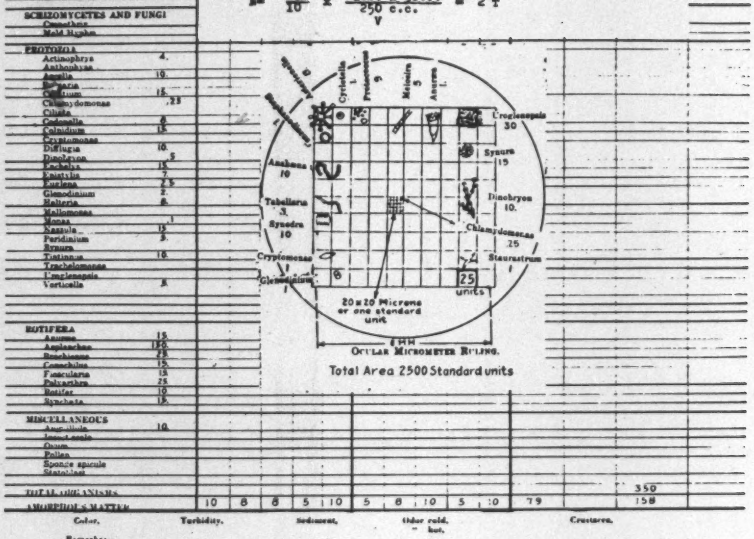

SCHIZOMYCETES AND FUNGI
Cryptomonas
Glenodinium
Tabellaria 3.
Synedra 10
Anabaena 10
Cryptomonas
Cyclotella 1.
Protococcus 9
Melosira 5
Anacaris 1.
Croglenopsis 30
Synura 15
Dinobryon 10.
Chlamydomonas 25
Staurastrum 1
25 units
20 x 20 Microns or one standard unit
Ocular Micrometer Ruling.
Total Area 2500 Standard units
ROTIFERA
Anuraea 15.
Asplanchna 150.
Brachionus 25.
Conochilus 15.
Fuscularia 15.
Polyarthra 25.
Rotifer 10.
Synchaeta 15.
MISCELLANEOUS
Angulula 10.
Insect scale
Ovum
Pollen
Sponge spicule
Statoblast
TOTAL ORGANISMS
AMORPHOUS MATTER
Color.
Turbidity.
Sediment.
Odor cold.
" hot.
Crustacea.
Remarks:—
By Samuel O. Swartz
Metropolitan District Commission-Water Division
Boston, Mass.

FIG. 2.

ALGAE

MICROSCOPIC ORGAN

BY SAMUEL
Bacteriologist-Mate

DIATOMACEÆ

CYANOPHYCEÆ

SCHIZOMYCETES - FUNGI

ROTIFERA

MISCE

AE CHART

Copyright 1899

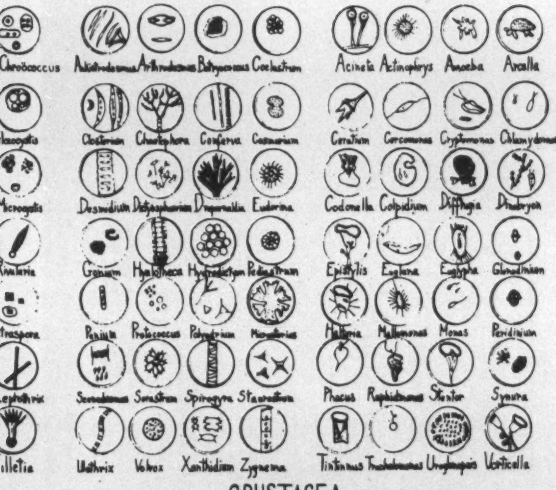
GANISMS IN WATER SUPPLIES

SAMUEL O SWARTZ
...t - Metropolitan Water, Boston, Mass.

E

CHLOROPHYCEÆ

PROTOZOA



CRUSTACEA

CELLANEOUS

FIG. 1.

It is necessary to become familiar with the various microscopic forms, to accomplish the counting of organisms. An "Algae Chart" which the author has compiled will assist the water-supply workers to identify organisms (see Fig. 1).

The accompanying chart (Fig. 2) also shows the approximate values and estimates of algae carried on in the biological laboratory of the Metropolitan Water Works, Boston, Mass. The chart represents a sample sheet used at this laboratory, with the various organisms arranged in their proper groups.

A 250-cc portion of the water to be examined for microscopic organisms is filtered through a cylindrical funnel, fitted with a one-hole rubber stopper at the bottom. A cloth disc of silk, about 200-mesh to the inch, is placed over the hole in the stopper and covered with white beach sand, passing a screen having 60 meshes per inch and retained on a screen of 120 meshes per inch. When water has filtered, all algae are caught in the sand.

The sand is then washed out with 5 cc of distilled water into a test tube. The tube is rotated slowly and the sand is allowed to settle. The water is decanted into another test tube. This concentrate is then examined microscopically, ten fields being counted at random on a slide holding one cubic centimeter of filtered water. All organisms are evaluated through the ocular micrometer ruling, all algae being estimated as shown on Figure 2. Amorphous matter is an individual's determination, based on clumping all debris in a large square and approximating a count. All organisms are observed and calculated on a microscope with a 10x ocular, 7.5 objective; the draw-tube length should be 160 millimeters.

Taste and odor control can be gained by establishing a definite figure showing the presence of an undesirable organism and treating chemically to eradicate the condition. It is essential, before attempting to treat with copper sulphate, to determine the organisms causing the objectionable condition. There is no fixed dosage of copper sulphate suitable for any one condition, as temperature and pH affect the desired results in various localities. The following troublesome algae are observed periodically in the reservoirs of this supply, and treatment with copper sulphate is made before the organisms have reached the estimated figures indicated:

	Standard units per cc
Asterionella	3,000
Tabellaria	2,500
Synedra	3,000
Aphanizomenon	1,000
Anabaena	600
Cryptomonas	200
Chlamydomonas	10
Dinobryon	500
Synura	200
Uroglenopsis	200

The troublesome organisms are reduced in the Metropolitan Water System by chlorination, before reaching the main point of distribution, so that taste and odors are at a minimum.

When copper sulphate treatment is necessary, 2½-3½ lb per mil gal have been found satisfactory during the summer months (when the water is warm) and 3-4.2 lb per mil gal have been used in the winter.

Most people are interested in the water they drink. As long as it is satisfactory there is no complaint, but let there develop an odor or taste and immediately one becomes suspicious and hesitates to use that water, until its safety for drinking has been established. Water for municipalities is obtained either from surface supplies—that is, ponds, lakes or reservoirs—or from ground supplies, such as well water. A few supplies may be derived from a mixture of surface and ground waters. In surface supplies, open to the influence of heat, light and air, spores are apt to appear. These come from the dust in the air or from other sources and, in the presence of organic matter, either nitrogenous or carbonaceous, develop into plants so small that, with very few exceptions, they can be seen only by the aid of the microscope. These are called microscopic organisms. They may be of either plant or animal origin and are scattered throughout the entire body of water. They are divided into classes according to their shape, size and characteristics, and are known as Algae, Fungi, Protozoa, etc. Each of these classes is further divided into numerous specific organisms. Of these growths, each has its particular odor, characteristic of a specific organism. Just as certain flowering plants give rise to certain odors, due to the oil which they secrete, such as the rose and the violet,

so large quantities of *Anabaena* when present in reservoirs impart a marshy or moldy odor to the water; *Synura,* an odor of ripe cucumber, and *Uroglenopsis,* an oily odor or that of decayed fish. Many times the consumer is mistaken in thinking that this odor is caused by the actual presence of decayed fish in the reservoir.

There are usually many varieties of organisms growing in a reservoir at the same time. Ordinarily the number present is not sufficient to give a perceptible odor to the water. However, if conditions of temperature and food supply are more favorable for a particular species, it multiplies much more rapidly than the others and, if it has a characteristic odor, it will soon impart that odor to the water. The odor that these organisms produce is often intensified when they begin to die and decompose, or when they are broken up, as when flowing through the water mains or when the water is heated. Under these conditions, not only the strength of the odor will increase but its character will change so that, for instance, *Anabaena,* having a marshy or moldy odor in its living state, will, when it dies and decomposes, impart a strong pig-pen odor to the water. Sometimes the odor that a species or organism imparts to the water will not only increase as the number of organisms increases but will undergo a marked change in character. Thus *Asterionella,* when only a few of these organisms are present, gives an aromatic or geranium odor but, when the organism has increased in concentration, the odor changes to one resembling stale fish. In the summer months the temperature of the water at the bottom of deep reservoirs is lower than at the surface, and in winter it is higher than at the surface. In spring and fall, when the temperature of mid-depth approaches that of the surface and bottom, the whole body of water begins to turn over and with it the bottom organisms are drawn to the surface, and vice versa. For a short time there is apt to be an increase in the odor of municipal water supplies, due to the influx of broken-up organisms and aquatic plants. Odors in surface waters increase in intensity as the temperature of the water increases. Almost everyone is sensitive to the change in the temperature of the water he is accustomed to drink. For instance, water standing in pipes between the walls in larger buildings overnight becomes heated and acquires a flat taste and at times an unpleasant odor. This same water, however, when chilled would probably be most ac-

ceptable to the consumer. Many times, when municipal water supplies are drawn from large reservoirs, the water comes from one of three depths—surface, mid-depth or bottom. In case of any complaint from water consumers on the pipe lines regarding tastes and odors which may be due to abnormal growths of microscopic organisms in the water, it can sometimes be rectified by drawing from one of the other levels.

Clinical information regarding microscopic organisms' causing disease or a serious public-health condition has been vague. A definite study of *Cyclops* as a host for the guinea worm is shown by experimentation. This condition is quite evident in drinking-water supplies of India, Africa and Arabia. The disease is known as "dracontiasis". Further reference to this condition may be found in the book on "Practical Bacteriology, Blood Work and Animal Parasitology" by E. R. Stitt.

A paper submitted by F. A. Olsen on the "History of Toxic Plankton and Associated Phenomena" was printed in Sewage Works Engineering in February, 1949. The article states that "domestic animals may die after consuming algae-laden waters; also that one agent in algae poisons the liver, and another causes skin lesions." Investigators could not isolate or determine its exact nature.

The possible relation of toxic algae in surface-water supplies should be studied and isolated. No condition or evidence of any nuisances due to peak occurrences of organisms has been recorded in the New England area.

The control or elimination of algae nuisances, thus far, is temporary and requires the constant vigilance of the water-supply personnel.

MEMOIR OF
DANIEL WEBSTER MEAD

Daniel Webster Mead, a member of the New England Water Works Association since 1900, passed away October 13, 1948. Dr. Mead was born at Fulton, N. Y., on March 6, 1862. His early life was one of hardship, which formed in him a stoicism that served him well throughout his career. As early schooling had to be supplemented by work, he entered the employ of E. F. and John Barnes Manufacturing Co. at Rockford, Ill., where he worked as a machinist until he was able to enter Cornell University in 1881, which he did as a sophomore.

After graduation in 1884, his first position was with the Glacial Division of the U. S. Geological Survey, where he worked in the field of hydrology. After about a year he was offered the position of City Engineer for the city of Rockford, Ill., which he held until 1888, when he organized The Rockford Construction Co., of which he became Engineer and General Manager.

For about ten years he continued in the contracting field, designing and constructing many small water supplies and other municipal improvements throughout the Middle West. In 1899, however, he returned to the professional field, opening an office in Chicago as consulting engineer on power plants and hydraulic works. Five years later the University of Wisconsin appointed him head of the newly formed Department of Hydraulics and Sanitary Engineering. This necessitated his moving to Madison. The Chicago office, however, was continued until 1907, when as a matter of convenience the consulting service also was transferred to Madison.

In 1914 Dr. Mead was sent to China by the American Red Cross, to study and make recommendations on flood control of the Huai River. He served as principal consultant for the Miami Conservancy District in connection with flood-control reservoirs on the Miami River; he was a member of the Colorado River Board, appointed by President Coolidge to pass on the Hoover Dam project; and he was

Chairman of a Board of Review of the Public Works Administration in connection with sewage-disposal works for the Chicago Sanitary District. Outstanding also were instances where he advised in connection with dam failures, such as at Austin, Tex.; Elwha Dam on the Olympic Peninsula; and Stony River Dam, West Virginia.

On taking up his work at the University of Wisconsin, Dr. Mead published privately his "Notes on Hydrology" for use in the course he introduced. By 1919 this document had been expanded into his 647-page textbook, "Hydrology." Meanwhile, his increasing consulting practice in the hydro-electric power field had resulted in the publication of "Water Power Engineering," long the standard work on this subject. In 1916 he had published "Contracts, Specifications and Engineering Relations," the result of his contracting experience; in 1930 his two-volume work, "Hydraulic Design," appeared, and two years later the book, "Hydraulic Machinery." The scope of these works, not to mention the host of papers contributed to various professional societies and periodicals, indicates the breadth of his knowledge and influence in the field of Hydraulic Engineering.

Upon his retirement in 1932, the University of Wisconsin conferred on him the degree of Doctor of Laws. He received numerous awards of medals for papers before professional societies.

Dr. Mead was a member of four college fraternities; a member of the American Institute of Consulting Engineers; Past-President and Honorary Member of the American Society of Civil Engineers; Honorary Member of the American Water Works Association; Fellow of the American Institute of Electrical Engineers and the American Public Health Association; and a member of the American Society of Mechanical Engineers, the Western Society of Engineers and several other scientific societies.

That his interest was not limited to engineering is proved by his having been active as a Director of the First National Bank of Madison, Wis.

In 1886 he married Katie Ross Gould, who passed away in 1944. Of their six children three survive him, Hazel M. Jenks, Harold W. Mead and Dr. Franklin B. Mead.

Though of stern mien, Dr. Mead possessed a quiet humor, which, combined with his serious disposition and kindliness, served to endear

him to pupils and friends alike. As evidence of this is the citation presented to him in 1939 by 25 colleagues in the College of Civil Engineering at the University of Wisconsin:

> "Daniel Webster Mead, great engineer, wise mentor, practical idealist, who with signal success has practiced and advanced a profession, who has ever demonstrated the capacity for right thinking and fearless speaking, and who, amidst the exigencies of professional service, has for 30 years found time to act as teacher, counselor, and friend to many."
>
> FRANK A. MARSTON

MEMOIR OF

ERNEST BATEMAN BLACK

Ernest Bateman Black was born at Mt. Sterling, Ill., on January 13, 1882, and died, after several years of ill-health, of a heart attack at his home on July 4, 1949. He is survived by his wife, two sons and two daughters.

During boyhood he assisted his father, Moses Black, a surveyor of Meade County, Kansas, in land and irrigation surveys. This was followed by study at the University of Kansas, from which he was graduated in 1906 with the degree of Bachelor of Science in Civil Engineering.

His first position was with the Atchison, Topeka and Santa Fe Railroad as masonry inspector, but he left shortly in order to enter the employ of Riggs and Sherman in Toledo, O., where he gained experience in water-supply and sewage-disposal problems. In 1909 with John S. Worley, a fellow employee, he moved to Kansas City and formed the partnership of Worley and Black. This firm carried on an active practice in municipal sanitation and valuation work until 1914, when Mr. Worley was appointed by the Interstate Commerce Commission to assist in government valuation of railways.

The following year Mr. Black entered into partnership with N. T. Veatch, Jr., and formed the firm of Black & Veatch, an organization

which has now expanded to a group of between three and four hundred engineers and employees.

In addition to acting as consultant on water-supply and sewerage problems, Mr. Black has testified extensively in cases having to do with valuation and appraisal, such as the Cities Service Gas Co. case, for the Public Service Commission of Kansas, which established the right of the State to regulate companies doing an interstate business; the Lone Star Gas Co. investigation for the city of Fort Worth; the East Ohio Gas Co. case for the city of Cleveland; Oklahoma Natural Gas Co. valuation, for the Corporation Commission of Oklahoma; and appraisal for the city of Cincinnati of the Cincinnati Gas and Electric Co.

During both World Wars Mr. Black rendered valuable service to the War Department in connection with the selection of sites for camps, the design and supervision of their construction, and the recommendation of camp utilities.

The scope of Mr. Black's activities, however, extended far beyond those required to meet the demands of his profession. He was a member of various engineering organizations, including the American Institute of Consulting Engineers, American Society of Civil Engineers —of which he was President in 1942—Society of American Military Engineers, and American Water Works Association; Past President of the Missouri Society of Professional Engineers, and a member of the New England Water Works Association since 1914. He always took an active interest in the affairs of his Alma Mater, serving as President of the Alumni Association, member of the Board of Alumni Directors, and member of the Board of Directors, University of Kansas Research Foundation.

The geniality and sympathetic quality of his nature were manifested in his great interest in the progress of young engineering students and urged him into Boy Scout leadership. He was a Mason and a Shriner, member of Sigma Xi, Tau Beta Pi, and several other clubs. He has left a record of distinguished service to the engineering profession and of kindness and loyalty in his human relationships.

FRANK A. MARSTON

MEMOIR OF
PHILIP E. BOND

Philip E. Bond, who was well known as a consulting engineer in western Massachusetts, died at Holyoke, Mass., on August 18, 1949, following a short illness.

Mr. Bond was born in Holyoke May 13, 1894. After graduating from Holyoke High School, he entered the University of Michigan, from which he received the degree of Bachelor of Civil Engineering in 1916.

His early years following his graduation found him in widely scattered places, where engineering skill was needed, such as Flint, Mich., New York, N. Y., and Barabona, Santo Domingo. During the first World War he served in the U. S. Navy with the rank of ensign.

After a year or two as a member of the firm of Franz & Bond, architects and engineers, Mr. Bond was appointed City Engineer of Holyoke in 1923. He held this position until 1938, except for a brief period in 1926. In the latter year he became associated with the late James L. Tighe as a member of the firm of Tighe & Bond, consulting engineers, in Holyoke. After Mr. Tighe's death in 1947, Mr. Bond became head of the firm. He specialized in sanitary engineering and, in recent years, he had been consultant for a dozen or more municipalities in the western part of Massachusetts relative to water and sewerage problems.

Mr. Bond was a member of the New England Water Works Association, the American Water Works Association, the American Society of Civil Engineers, the American Society of Municipal Engineers and the New England Sewage Works Association. He was also a member of the American Legion and of the William Whiting Lodge of Masons.

He is survived by his widow, Mrs. Dorothy Brooks Bond; a son, Philip E., Jr.; a daughter, Janet; two brothers, William and Raymond; and two sisters, Mrs. Gilbert Brown and Mrs. H. L. Gants.

GEORGE C. HOUSER

MEMOIR OF
WILLIAM JAMES EAMES BINNIE

William James Eames Binnie, Honorary Member of the New England Water Works Association, died on October 4, 1949, at Tilehurst, Berks, England.

Mr. Binnie was born on October 10, 1867, in Londonderry, Ireland. He was educated at Rugby and Cambridge, England, and at Carlsruhe, Baden. He was graduated from Cambridge in 1888 with high honors.

In 1902, after several years of employment in subordinate but important capacities, he joined the consulting firm headed by his father, Sir Alexander Binney, from which he retired in 1948. Mr. Binnie's professional career was a long and outstanding one. His services as a consultant were employed on notable engineering works in the British Isles and colonies. Among these works were many relating to water supply and water-power development. In addition he served as a member of governmental commissions and as advisor to others having to do with water-supply and water-power engineering.

Mr. Binnie was a Past President of the Institution of Civil Engineers, the Institution of Water Engineers, the Institution of Sanitary Engineers, and of the British Section of the Société des Ingénieurs Civils de France. He was made an Honorary Member of the New England Water Works Association in 1934, of the Institution of Water Engineers in 1936 and of the American Society of Civil Engineers in 1939. For his services to the Société des Ingénieurs Civils, the French Ambassador to Britain conferred the Legion of Honor upon him in 1948.

Mr. Binnie lost two sons in the late war, but a surviving son continues as a third-generation member of the firm founded by his grandfather, now known as Binnie, Deacon and Gourley.

Mr. Binnie was a man of broad interests and culture, withal modest and kindly. Those who were privileged to know him have lost a valued friend, and the water-works profession, a distinguished engineer.

E. SHERMAN CHASE

BOOK REVIEW

The Examination of Waters and Water Supplies (Thresh, Beale & Suckling)—*Sixth Edition.* By Edwin Windle Taylor. xii + 819 pp. Philadelphia, Pa.: The Blakiston Company, 1949. $12.00.

This book, which has been a well-known reference work for more than 40 years, deals with both analysis and purification of waters for public water supply. While it is written primarily from the standpoint of British practice, it contains numerous data on American and Canadian practice, together with material relative to many other parts of the world.

As the three original authors had died, the present author prepared the sixth edition for the purpose of bringing the contents of the book up to date and, at the same time, retaining its original format. In order to prevent the book from becoming unwieldy in size, it was necessary to set up some sub-sections and paragraphs in smaller type.

The entire subject-matter has been carefully revised, and the chapters on gathering grounds and underground supplies have been rewritten. Moreover, the chapters on waterborne disease, bacteriology of water samples and disinfection of water supplies have been extended and rewritten.

The book is divided into the following parts:

I. Geological Considerations and Suitability of Water for Public Supply Purposes
II. Inspection of Waterworks and Sources of Supply
III. The Scope of Physical, Biological and Chemical Examinations
IV. Analytical Processes and Methods of Examination
V. Analytical Characters of Waters in Relation to Their Geological Origin
VI. The Bacteriological Examination of Water
VII. Results and Standards in the Examination of Samples of Water

VIII. Water Supplies and Disease
IX. The Purification and Treatment of Water

The volume contains 52 illustrations, together with numerous tables and a 42-page appendix. The usefulness of the book has been extended by a three-fold increase in the number of references to scientific literature relative to recent work on analysis and purification of water supplies.

GEORGE C. HOUSER

PROCEEDINGS

November 1949 Meeting

Hotel Statler, Boston, Mass.

Thursday, November 17, 1949

President Sidney S. Anthony in the Chair.

Secretary Knox announced the election of the following to membership in the Association:

James W. Burrowclough, Superintendent, Stone Bridge Fire District Water Department, Tiverton, R. I.; John W. Costigan, Water Registrar and Clerk, Municipal Water Works, Springfield, Mass.; Herbert F. Howe, City Engineer and Director of Public Works, Waltham, Mass.; Edward R. Lawson, Superintendent, Board of Public Works, Andover, Mass.; Francis N. O'Hara, General Foreman, Water Department, Arlington, Mass.; Maurice Brunstein, Superintendent and Engineer, Water Department, Atlantic City, N. J.

Members Reinstated:

Roger W. Macdonald, Town Manager, Middleborough, Mass.; Edward J. Murphy, Registrar, Water Department, Holyoke, Mass.

Associate Member:

Pioneer Foundry & Manufacturing Co., Inc., Gilbertsville, Mass.

A paper on "Improving Water Quality by Cleaning Reservoirs and Draining Swamps" was read by Marshall S. Wellington, Sanitary Engineer, New Haven Water Co., New Haven, Conn.

A paper on "Power Generation from the Delaware Aqueduct" was read by George R. Rich, Partner, Charles T. Main, Inc., Boston, Mass.

Colored moving pictures of the submersible pump were shown by the Byron Jackson Co. and the Hayes Pump and Machinery Co., Boston, Mass.

December 1949 Meeting

Hotel Statler, Boston, Mass.

Thursday, December 15, 1949

President Sidney S. Anthony in the Chair.

President Anthony. On your programs, which were sent you last week, there is contained on the back an amendment to the Constitution of the Association. This amendment is brought about by the fact that our arrangements for our next Convention have necessitated opening the Convention on Monday and, since the Constitution has previously provided that the Convention shall open on a Tuesday we must amend the Constitution as follows:

> "Section 1, Art. VIII, of the Constitution is hereby amended by striking out the words 'on such Tuesday,' so as to read as follows:
>
> " 'Section 1, Art. VIII. The Annual Convention of the Association shall open at such time and place in September as the Executive Committee shall designate.' "

Is there any discussion of this proposed amendment before it is put to a vote? [No response.] If not, I will ask those who are in favor of the amendment to the Constitution to this extent to raise their right hands. Is there any opposition? I declare it a vote and the Constitution is now amended.

Now that you have legalized the action of the Executive Committee I will announce that the 1950 Convention will open on September 17 at Poland Spring, Me., and end on September 20. The 1951 Convention has been arranged for September 10-13 at the Statler Hotel in Boston.

A paper on "Current Hydrologic Conditions in New England" was read by Charles E. Knox, Hydraulic Engineer, U. S. Geological Survey, Boston, Mass.

A talk on "The Proposed New England Steel Mill" was given by Ray M. Hudson, Secretary of the New England Council Iron and Steel Committee, Boston, Mass.

An illustrated talk on "Water Supplies for Army Bases in Alaska" was given by William L. Hyland, Partner, and George M. Reece, Sanitary Engineer, Fay, Spofford & Thorndike, Boston, Mass.

JANUARY 1950 MEETING

HOTEL STATLER, BOSTON, MASS.

THURSDAY, JANUARY 19, 1950

President Sidney S. Anthony in the Chair.

The President announced the election of the following to membership in the Association:

Wendell F. Esty, Chief Mechanic, Water and Sewer Works, Danvers, Mass.; Frederick J. Haydock, Chief Engineer, Walnut St. Pumping Station, Lynn, Mass.; Neil B. Faunce, Superintendent, Public Works, Whitman, Mass.; George T. Stewart, Superintendent, Chelmsford Water District, Chelmsford, Mass.; William D. Twombly, Superintendent, Water Department, Groveland, Mass.; Frederick B. Wood, Chairman, Board of Water Commissioners, Townsend, Mass.; Mathew C. Allan, Kent County Galvanizing Co., Hillsgrove, R. I.

Reinstated Member:

Charles R. Moore, Water Works Engineer, Portland Water District, Portland, Me.

Junior Member:

Morton I. Goldman, Graduate Student, Massachusetts Institute of Technology, Cambridge, Mass.

A paper on "Residual Chlorine in Water—Production and Identification" was read by A. E. Griffin, Director, Technical Service Division, Wallace & Tiernan Co., Inc., New York, N. Y.

A paper on "Use of Mechanical Equipment in Laying Pipe" was read by J. G. Carns, Jr., Water Works Service Co., Inc., New York, N. Y.

A paper on "Functions, Duties and Authority of the Public Health Service on Water-Pollution Control" was read by Leonard W. Trager, Drainage Basin Engineer, New England Drainage Basin, U. S. Public Health Service, Boston, Mass.

SULFUR JOINT COMPOUNDS

The Journal of the American Water Works Association for December, 1949 (p. 1079), contains "Tentative Standard Specifications for Installation of Cast-Iron Water Mains", which have been approved as tentative by the Board of Directors of the American Water Works Association. It is noted that sulfur joint compounds have been omitted from these specifications, "pending the completion of investigations now in progress."

The New England Water Works Association's Committee on Laying Cast-Iron Water Mains coöperated with the corresponding committee of the American Water Works Association in formulating the above-mentioned specifications. However, the N. E. W. W. A. committee has not yet made a final report. So that it may have the benefit of the thought and experience of members of this Association in preparing its final report, the committee will be glad to receive comments on, and reports of experience with, the sulfur joint compounds. Communications should be sent to W. S. Mariner, Chairman, 1300 Statler Building, Boston 16, Mass.

REVISION OF RECOMMENDED PRACTICE FOR TANK INSPECTION, REPAIR AND REPAINTING*

The following changes, approved by the Association's Board of Directors on September 26 and 28, 1949, are to be made in the A.W.W.A. "Tentative Recommended Practice for Inspecting, Repairing and Repainting Elevated Steel Water Storage Tanks, Standpipes and Reservoirs—7H.2-T"‡:

1. Introduction, Paragraph 10 (of the numbered paragraphs). Add the phrase in italics: "*While the use of the contractor's contract form is not recommended,* if the owner chooses to engage in letting contracts for painting and repair on contract forms other than his own, he should first submit them to his attorney, asking him to study them carefully to see: . . . ."

2. Sec. 2A-1.4—Draining of Tank. The second sentence is changed to read: "The inside surfaces should be thoroughly washed down by the owner to remove slime from wall surfaces and loose deposits and dirt from the tank bottom before the inspector arrives."

3. Sec. 2A-2.1—Condition of Paint. Item (1) is changed to read: "Rough approximation of per cent of rust area."

4. Sec. 2A-2.2—Pitting. Insert the phrases in italics: "Determine and report upon the extent and depth of pitting *in the area selected, scaled and cleaned by the inspector. The dimensions and locations of each area scaled and cleaned are to be reported.* The extent *of pitting found* should be described both as to location and character. The record of depth of pitting should be *as specific as practicable* as to location, area affected, whether blotchy, deep, pin-point or general corrosion."

5. Sec. 2A-2.3—Type of Repairs. In the second sentence, add the phrase in italics: "If they can be repaired by patches, the inspector shall specify, *to the extent practicable,* the size, location and number of patches."

6. Sec. 2A-3.1.10—*Paint.* In Item (5), insert the phrase in italics: "The condition of the paint and metal inside of the tank shall, *based on the areas carefully examined and other information gained by the inspector.*" At the end of Item (9), insert the phrase: "*of the tank.*" At the end of Item (10), insert the phrase: "*of the riser pipe.*"

7. Sec. 2A-3.1.11—*Rivets.* Insert the phrase in italics: "Report, *by selecting, scaling and examining suitable areas,* the condition of the rivets at lap joints and post connections."

8. Sec. 2A-3.1.12—*Metal.* Insert the phrase in italics: "Report, *by selecting areas to be examined,* the condition of the metal between the rivets at the laps and at the post connections."

9. Sec. 2A-3.1.14—*Prior Painting.* Insert the words in italics: "(1) When was the tank *reported to have been* last painted? (2) What material was *reported* used?"

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*Reprinted from Jour. A. W. W. A., *41*:11, 1046, Nov., 1949.

‡See Jour. N. E. W. W. A., *62*:4, Dec., 1948.

Note: The above revisions were accepted by the Executive Committee of the New England Water Works Association on January 19, 1950.

10. Sec. 2B-1.2—Inspection Recorded. In the second sentence, insert the phrase in italics: "The bidders shall familiarize themselves with the report and the conditions of the structure and, upon request to the owner *and under such conditions as the owner may prescribe,* may make such further inspection as they consider necessary prior to submitting proposals."

11. Sec. 2B-1.3—Work to Be Itemized. In the first sentence, insert the words in italics: "The owner shall itemize repair work by units, such as the number of patch plates to be welded to the structure and their *approximate average* area; the lineal feet of welding *or calking* to make the seams watertight; . . . ."

12. Sec. 2B-3—Watertightness. In the last sentence, add the phrase in italics: "Payment for repair work shall not be made until and unless the job is watertight *in the areas in which the contractor was called upon to make repairs to secure watertightness.*"

13. Sec. 2C-1.2—Damage to Tank. The third sentence is changed to read: "If, in the process of removing old paint or carrying out the work specified in the contract, any leaks develop which in the opinion of the owner were caused by negligence, lack of skill or other act or omission on the part of the painting contractor, such leaks shall be repaired by the painting contractor without additional remuneration; . . . ."

American Water Works Association

Tentative

Standard Specifications

for

REINFORCED CONCRETE WATER PIPE—STEEL CYLINDER TYPE, PRESTRESSED

These "Tentative Standard Specifications for Reinforced Concrete Water Pipe—Steel Cylinder Type, Prestressed" are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and must be reviewed by the engineer responsible for the construction and modified as necessary to meet specific conditions pertaining to each individual installation.

Approved as Tentative by the Board of Directors of the A.W.W.A. on November 21, 1949

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Incorporated
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Prepared by

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Tentative Standard Specifications for

Reinforced Concrete Water Pipe—Steel Cylinder Type, Prestressed

Section 2–1—General

Sec. 2–1.1—Scope

These specifications cover the manufacture of circumferentially prestressed reinforced concrete water pipe with steel cylinder in sizes from 16 to 48 in., inclusive, designed for static heads ranging from a minimum of 100 ft. to a maximum of 600 ft. The specifications do not include delivery, laying, field testing or sterilization of the pipe.

Sec. 2–1.2—Definitions

In these specifications the following definitions will apply:

1.2.1. *Purchaser.* The word "purchaser" shall mean a person, firm, corporation or governmental subdivision entering into a contract or agreement to purchase any materials, or have any work performed, according to these specifications.

1.2.2. *Contractor.* The word "contractor" shall mean the person, firm or corporation executing the contract or agreement with the purchaser to furnish any materials or perform any work according to these specifications.

1.2.3. *Manufacturer.* The word "manufacturer" shall mean the person, firm or corporation who actually manufactures the pipe, acting either directly as the contractor, or as a subcontractor. If the manufacturer is acting as a subcontractor under the contractor, the obligations of the manufacturer under these specifications shall be considered as obligations of the contractor, and the contractor shall be responsible for their performance.

1.2.4. *Engineer.* The word "engineer" shall mean the engineer employed by the purchaser and acting as his representative; the purchaser himself, acting as his own engineer; and their respective assistants and inspectors.

1.2.5. *A.S.T.M.* The term "A.S.T.M." shall mean the American Society for Testing Materials. When specific A.S.T.M. specifications are cited, the designation shall be construed to refer to any subsequent revision under the same specification number, or superseding specifications under a new number, except as to provisions in the revised specifications which clearly are inapplicable.

1.2.6. *Approved.* The term "approved" shall mean having received the approval of the engineer.

Sec. 2–1.3—Essential Requirements

The pipe shall have the following principal features: a welded sheet-steel cylinder with steel joint rings welded to its ends; a lining of dense concrete within the steel cylinder; reinforcement consisting of high-tensile wire wound around the outside of the steel cylinder at a predetermined tension and securely fastened to it at its ends; a coating of dense mortar or concrete covering the

cylinder and wire except for necessarily exposed surfaces of the joint rings; a self-centering joint with a preformed gasket of rubber, so designed that the joint will be watertight under all conditions of service.

Sec. 2–1.4—Plans and Data Furnished by Purchaser

It is understood that the purchaser shall furnish to the contractor plans and profiles of the pipeline showing: alignment and grades; the location of all outlets, connections and special appurtenances; the design head for each portion of the pipeline; and such special details as are necessary for the manufacture of the pipe and fittings in accordance with these specifications and with the specific requirements of the work for which the pipe is made.

Sec. 2–1.5—Supplementary Details Specified by Purchaser

When purchasing pipe under these specifications, it will be necessary for the purchaser to make supplementary statements specifying: the manner of storage and delivery, if these are required of the contractor or manufacturer; and the type of specials and fittings to be furnished.

Sec. 2–1.6—Data Submitted by Contractor

1.6.1. Drawings and schedules showing full details of reinforcement, concrete and joint dimensions for the pipe shall be furnished by the contractor. All drawings and schedules shall be submitted for approval in quadruplicate, and one copy shall be returned to the contractor after approval. No pipe shall be manufactured until the drawings have been approved.

1.6.2. When specifically required, the data submitted by the contractor shall include a tabulated layout schedule, with reference to the stationing and grade line shown on the contract drawings. The schedule shall show pressure zones, each of which shall be designated by the design head applicable therein, and the point of change from one zone to the next shall be clearly indicated by station number. The diameter of pipe, the design head, and the thickness of pipe wall and area of steel (per linear foot of pipe) in the reinforcing wire and steel cylinder shall be listed for each portion of pipeline for which the design head or the equivalent internal pressure is fixed by the purchaser.

Sec. 2–1.7—Marking

Each special and each length of straight pipe shall have plainly marked on the bell end the identification marks specified by the purchaser. These shall include, as specified, either the head for which the pipe or special is designed or the area of effective circumferential reinforcement per foot of pipe wall. Special marks of identification, sufficient to show the proper location of the pipe or special in the line by reference to layout drawings and schedules specified under Sec. 2–1.6 of these specifications, shall be placed on the pipe if specifically required. All beveled pipe shall be marked with the amount of the bevel.

Sec. 2–1.8—Inspection

1.8.1. The purchaser and his representatives shall have access to the work wherever it is in preparation or progress, and the contractor shall provide proper facilities for access and for inspection.

1.8.2. Inspection by the purchaser or his representatives, or failure of the purchaser or his representatives to

provide inspection, shall not relieve the contractor of his responsibility to furnish materials and to perform work in accordance with these specifications.

1.8.3. Material, fabricated parts and pipe which are discovered to be defective, or which do not conform to the requirements of these specifications, will be subject to rejection at any time prior to final acceptance of the pipe. Rejected material and pipe shall promptly be removed from the site of the work.

Sec. 2–1.9—Material and Workmanship

All material furnished by the contractor shall be new and of the quality specified. All work shall be done in a thorough, workmanlike manner by mechanics skilled in their various trades.

Sec. 2–1.10—Tests

1.10.1. The contractor shall furnish, in advance of the manufacture of steel cylinders and reinforcing cages, mill-test reports on each heat from which the steel is rolled, if required.

1.10.2. The contractor shall provide test specimens cut on the job from each shipment of steel for reinforcing and for cylinders, as directed by the engineer.

1.10.3. Each completed steel cylinder with joint rings welded to its ends shall be subjected to a hydrostatic test as specified herein under Sec. 2–3.5.4.

1.10.4. Frequent samples of the mixed concrete shall be taken for making up compression test cylinders as specified under Sec. 2–3.7.5.

1.10.5. If required by the engineer, the contractor shall submit test results showing the chemical and physical properties of rubber used in the gaskets.

1.10.6. The expense of the required mill tests of materials, and of testing the completed steel cylinders, shall be borne by the contractor. All other tests shall be made by representatives of the purchaser at the purchaser's expense, except as otherwise specifically provided.

Section 2–2—Material Specifications

Sec. 2–2.1—Cement

2.1.1. Cement for concrete work shall conform to the "Standard Specifications for Type I Portland Cement" (A.S.T.M. Designation C150–47), unless Type II cement is specified. Sampling and testing shall conform to the individual A.S.T.M. specifications designated therein.

2.1.2. Satisfactory facilities shall be provided for identifying, inspecting and sampling cement at the mill, the warehouse and the site of the work. The purchaser shall have the right to inspect the cement and obtain samples for testing at any of these points.

2.1.3. Cement shall be stored in a weathertight, dry, well ventilated structure approved by the engineer.

2.1.4. Cement salvaged by cleaning cement sacks, mechanically or otherwise, shall not be used in the work. Cement containing lumps will be rejected and shall immediately be removed from the site of the work.

2.1.5. If the temperature of the cement exceeds 150°F., it shall be stored until cooled to that temperature.

Sec. 2–2.2—Fine Aggregate

2.2.1. Fine aggregate for concrete and mortar shall consist of clean, hard,

durable and uncoated particles of natural sand or of sand prepared from the product obtained by crushing stone, gravel or other inert materials having similar qualities. The type of material shall be subject to the approval of the engineer. At the time of use the fine aggregate shall be entirely free of frozen material.

2.2.2. Fine aggregate shall be free from organic impurities to the extent that, when subjected to the color test for organic impurities, it shall produce a color in the sodium hydroxide solution not darker than that of Fig. 2 in the "Standard Method of Test for Organic Impurities in Sands for Concrete" (A.S.T.M. Designation C40–33).

TABLE 1

Gradation Requirements for Fine Aggregate

Sieve Size	Total Passing, by Weight *per cent*
⅜ in.	100
No. 4	95–100
No. 8	65–98
No. 16	45–80
No. 30	20–70
No. 50	5–50
No. 100	2–10
No. 200	0–5

2.2.3. Fine aggregate shall be of such quality that mortar composed of it, when tested by the "Standard Method of Test for Structural Strength of Fine Aggregate Using Constant Water-Cement Ratio Mortar" (A.S.T.M. Designation C87–44), shall have a compressive strength equal to that of similar specimens—of the same proportions and composed of the same cement and Ottawa sand—graded as specified in the "Method of Test for Compressive Strength of Hydraulic-Cement Mortars" (A.S.T.M. Designation C109–44).

2.2.4. Fine aggregate shall be well graded from coarse to fine and, when tested by means of laboratory sieves in accordance with the "Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates" (A.S.T.M. Designation C136–39), shall conform to the gradation requirements in Table 1.

The gradation requirements given in Table 1 represent the extreme limits for determining the suitability of fine aggregate under these specifications. To maintain uniformity of gradation for aggregate from any given source, a fineness modulus determination shall be made upon representative samples from that source. Thereafter the fineness modulus of all shipments therefrom shall not vary more than ± 0.20 from the fineness modulus of the representative sample.

Sec. 2–2.3—Coarse Aggregate

2.3.1. Coarse aggregate for concrete shall consist of hard, durable particles of crushed stone or crushed or uncrushed gravel conforming to the requirements and tests given in paragraphs 2.3.2 through 2.3.5.

2.3.2. Coarse aggregate shall be well graded from coarse to fine. The maximum size and gradation shall be subject to the approval of the engineer and shall be such that the concrete can be readily placed inside the cylinder, by the particular method used in placing it, to provide a solid, compact, homogeneous wall with a smooth surface. Tests for gradation of coarse aggregate shall be in accordance with the "Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates" (A.S.T.M. Designation C136–39).

2.3.3. Deleterious substances in coarse aggregate shall not exceed the amounts given in Table 2, as deter-

mined by sampling and testing procedures listed in the "Standard Specifications for Concrete Aggregates" (A.S.T.M. Designation C33–44).

2.3.4. Thin and elongated pieces, the maximum dimension of which exceeds five times the minimum, shall not be in excess of 10 per cent of the coarse aggregate by weight.

2.3.5. The coarse aggregate, when subjected to five alternations of the sodium sulfate test in accordance with the "Tentative Method of Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate" (A.S.T.M. Designation C88–46T), shall have a corrected loss not in excess of 12

TABLE 2

Permissible Amounts of Deleterious Substances in Coarse Aggregate

Material	Maximum Weight Limit *per cent*
Soft particles	4.00
Coal and lignite	0.50
Clay lumps	0.25
Material finer than 200 sieve	1.00
Combined total of above items	5.00

per cent, unless specifically permitted by the engineer.

Sec. 2–2.4—Samples of Concrete Aggregates

At least four weeks prior to mixing concrete, the contractor, if required, shall deliver in suitable containers, for preliminary approval, samples of not less than 1 cu.ft. each of fine aggregate and coarse aggregate. All samples shall be plainly labeled to indicate the source of the material, the date and the name of the collector Methods of sampling aggregates shall be in accordance with the "Tentative Methods of Sampling Stone, Slag Gravel, Sand and Stone Block for Use as Highway Materials" (A.S.T.M. Designation D75–46T).

Sec. 2–2.5—Water

Water used for concrete and for curing pipe shall be clean and free from oil, acid, strong alkalies or vegetable matter, and the source shall be approved by the engineer.

Sec. 2–2.6—Steel for Cylinders

Steel for cylinders shall conform to the "Tentative Specifications for Heavy Gage Structural Quality Flat Hot-Rolled Carbon Steel, Open-Hearth, Grade B" (A.S.T.M. Designation A245–48T), unless otherwise permitted. Where special operating conditions necessitate the use of sheets of higher tensile properties, sheets of special alloy steel may be used, subject to the approval of the engineer.

Sec. 2–2.7—Steel for Reinforcement

2.7.1. The wire for circumferential reinforcement shall be not less than $\frac{1}{8}$ in. in diameter and shall have high tensile characteristics. It shall be selected for applicability to the particular design conditions pertaining to the diameter and design pressure of the pipe. The type and size of wire shall be subject to the approval of the engineer and shall conform to one of the three following specifications: "Standard Specifications for Oil-Tempered Steel Spring Wire" (A.S.T.M. Designation A229–41); "Standard Specifications for Hard-Drawn Steel Spring Wire" (A.S.T.M. Designation A227–47T); or "Standard Specifications for Cold-Drawn Steel Wire for Concrete Reinforcement" (A.S.T.M. Designation A82–34).

2.7.2. Wire-mesh reinforcement for mortar coating for fittings shall conform to the "Standard Specifications for

Welding Steel Wire Fabric for Concrete Reinforcement" (A.S.T.M. Designation A185–37).

2.7.3. Steel wire reinforcement for concrete for fittings shall conform to "Standard Specifications for Billet-Steel Bars for Concrete Reinforcement, Structural Grade" (A.S.T.M. Designation A15–39).

Sec. 2–2.8—Steel for Joint Rings

2.8.1. Steel strips for bell rings less than $\frac{1}{4}$ in. thick shall conform to "Tentative Specifications for Hot-Rolled Strips of Structural Quality, Grade A" (A.S.T.M. Designation A303–47T).

2.8.2. Steel plate for bell rings $\frac{1}{4}$ in. or more in thickness shall conform to the "Tentative Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality, Grade A" (A.S.T.M. Designation A283–46T).

2.8.3. Special shapes for spigot joint rings shall conform to the "Standard Specifications for Boiler Rivet Steel and Rivets, Grade A" (A.S.T.M. Designation A31–40), except that paragraph 7(b) shall be waived, or to the "Tentative Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality, Grade A" (A.S.T.M. Designation A283–46T).

Sec. 2–2.9—Steel Castings for Fittings

Steel castings for fittings shall conform to the "Tentative Specifications for Mild- to Medium-Strength Carbon-Steel Castings for General Application, Grade 70–36, Normalized" (A.S.T.M. Designation A27–46T).

Sec. 2–2.10—Steel Plates for Specials and Fittings

Steel plates for specials and fittings shall conform to the "Tentative Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality, Grade B or C" (A.S.T.M. Designation A283–46T).

Section 2–3—Fabrication of Pipe

Sec. 2–3.1—General Requirements

3.1.1. In general, pipe shall have a minimum nominal length of 16 ft.; except for bends, reducers, closure pieces and other special fittings which may be made in shorter lengths.

3.1.2. Pipe shall be round and true and shall have smooth and dense finished surfaces. The mean internal diameter of any portion of each section of pipe shall not fall short of the nominal diameter or size specified by more than $\frac{1}{4}$ in.

3.1.3. The thickness of the core, which shall include the steel cylinder, and the minimum thickness of the coating for each size of pipe shall be as shown in Table 3. A tolerance of $\pm \frac{1}{8}$ in. will be permitted in core thickness.

Sec. 2–3.2—Design of Steel Reinforcement

The reinforcement of the pipe shall consist of a welded steel cylinder with high-tensile-strength wire wrapped around it under tension after the concrete lining has been placed and cured. The cylinder shall have a thickness not less than 16 gage, U.S. Standard, and shall be of approved thickness. The thickness of the steel cylinder, the size of the high-tensile wire and the spacing and tension under which it is wound shall be such that the steel cylinder and wire shall reach their respective

elastic limits simultaneously at a pressure equivalent to at least 2¼ times the normal water pressure for which the pipe is designed. The steel wire reinforcement and its application shall be such that it will compress the core sufficiently to prevent any tensile stress in the core at the design working pressure. The maximum centerline spacing of the wire shall not exceed 1 in. and the minimum shall be 0.3 in. The contractor shall submit calculations for the determination of details of the pipe reinforcement prior to the manufacture of any pipe, if such calculations are required by the engineer.

TABLE 3

Core Thickness and Minimum Coating Thickness

Pipe id.	Core Thickness (Including Cylinder)	Min. Coating Thickness	
		Mortar	Concrete
	in.		
16	1	¾	1
20	1¼	¾	1
24	1½	¾	1
30	1⅞	¾	1
36	2¼	¾	1
42	2⅝	¾	1
48	3	¾	1

Sec. 2–3.3—Joint Rings

The steel bell-and-spigot joint rings shall be so designed and fabricated that when the pipe is laid it will be self-centering. The rings shall be accurately formed and finished to obtain a close, sliding fit for the self-centering surfaces. The tolerance between the theoretical diameters and the actual diameters of the contact surfaces shall be such that the clearance shall not exceed $\frac{1}{32}$ in. Each ring shall be formed by one or more pieces of steel butt-welded together, either by a resistance welder or by a hand electric-arc weld. After welding, the rings shall be smoothed by grinding the rough surfaces of the weld flush with the adjacent surface. The rings shall be expanded by a press beyond their elastic limits so that they are accurately shaped. They shall be checked for size and shape on accurate templates before being welded to the cylinders. The minimum thickness of the completed bell or spigot rings shall be $\frac{3}{16}$ in. The rings shall conform to the details submitted by the manufacturer and approved by the engineer. The joint rings shall be so designed that, when the pipe is laid and the joint completed, the gasket will be enclosed on all four sides. The contact surfaces shall be smooth, to prevent cutting of the rubber gasket during installation. The portions of the joint rings which will be exposed after the pipe is cast shall be protected from corrosion by a metallic coating with a minimum thickness of 0.002 in., applied by an approved method. When specifically permitted, an approved nonmetallic coating may be used.

Sec. 2–3.4—Rubber Gaskets

3.4.1. The joint shall be sealed with a continuous ring gasket made of a special composition rubber of such size and cross section as to fill completely the recess provided for it. The gasket shall be the sole element depended upon to make the joint watertight and shall have smooth surfaces free from pitting, blisters, porosity and other imperfections. The rubber compound shall contain not less than 65 per cent by volume of first-grade natural crude rubber. The remainder of the compound shall consist of pulverized fillers free from rubber substitutes, reclaimed rubber

and deleterious substances. The compound shall meet the following physical requirements when tested in accordance with appropriate sections of "Methods of Physical Tests and Chemical Analyses for Rubber Goods" (Federal Specification ZZ–R–601 and 601A):

Tensile strength. The tensile strength of the compound shall be at least 2,700 psi.

Elongation at rupture. Two-inch gage marks shall stretch to not less than 10 in. at rupture.

Specific gravity. The specific gravity shall be between 1.15 and 1.23.

Cold flow test. The percentage of cold flow—computed as 100 times the change in thickness divided by the original thickness—shall not exceed 12 when tested by subjecting a disk of the material, $\frac{1}{4}$ in. thick by $\frac{3}{4}$ in. in diameter, to a pressure of 600 psi., using a spring pressure device placed in an air oven at a temperature of 158°F. for 24 hours.

Tensile strength after aging. The tensile strength of the compound, after being subjected to an accelerated aging test for 96 hours in air at 158°F., shall not be less than 80 per cent of the tensile strength before aging. The test shall be that described in "Methods for Testing Rubber Goods" (Federal Specification ZZ–R–601–A, Sec. 2, Par. 14).

3.4.2. The contractor shall submit for approval details of the shape and size of the gaskets he proposes to furnish. If required by the engineer, the contractor shall also submit test results showing the chemical and physical properties of the materials used in the manufacture of the gaskets.

Sec. 2–3.5—Fabrication of Steel Cylinders

3.5.1. The cylinders shall be formed by shaping and welding together steel sheets of specified material and thickness. The cylinders shall be accurately shaped to the size required, and the joint rings shall be welded to the ends before testing.

3.5.2. The manufacturer may use either lap welding or butt welding for all longitudinal and circumferential welds. All welds shall be made downhand by the manual or automatic shielded-arc process. Welding shall be done so that there shall be thorough fusion and complete penetration. Prior to welding, the sheets shall be fitted closely and during welding shall be held firmly together. The manufacturer shall submit for approval, if required, the specific details of materials and methods he proposes to use before any welding is done.

3.5.3. Specimens for tensile and bending tests of welds shall be furnished by the contractor to the engineer as required. The number of cylinders from which test specimens are required to be cut shall not exceed one in every 3,000 ft. of pipe; provided that, if tests indicate the welding is unsatisfactory, the contractor shall furnish additional samples as required by the engineer. Cylinders from which test specimens have been cut may be patch-welded in an approved manner and used in the work The test specimens, procedure and results shall conform to the requirements of the "Reduced Section Tensile Test" and the "Free Bend Test" described in Sec. 3–5.1, 3–5.2 and 3–5.3 of "Standard Specifications for Electric Fusion Welded Steel Water Pipe of Sizes 30 Inches and Over" (A.W.W.A. 7A.3–1940). The expense of the welding tests shall be borne by the purchaser.

3.5.4. Each steel cylinder, with joint rings welded to its ends, shall be subjected to a hydrostatic test under a

water pressure which stresses the steel to a unit stress of at least 20,000 psi. but not greater than 25,000 psi. While under pressure test, all welds shall be thoroughly inspected and all parts showing leakage shall be marked. Cylinders which show any leakage under test shall be rewelded at the points of leakage and subjected to another hydrostatic test. The finished cylinder, with joint rings attached, shall not be used in the work unless it is completely watertight under the required test pressure.

Sec. 2-3.6—Placing of Wire Reinforcement

The high-tensile wire shall not be wound around the cylinder until at least seven days after the concrete lining is placed, unless otherwise specifically permitted, and until the concrete has reached the minimum seven-day compressive strength specified under Sec. 2-3.7.8 of this document. The net compression induced in the concrete lining of the core shall not exceed 40 per cent of the compressive strength of the concrete at the time of wrapping. Methods and equipment for applying the wire shall be such that it will be wrapped around the cylinder in a helical form at the designed predetermined spacing and tension for the full length of the cylinder. At the ends of the pipe, the wire shall continue for one extra circumferential lap. Methods for fastening the wire at the ends of the cylinder and for splicing wires shall be such that the connections will develop a strength equivalent to the strength of the wire.

Sec. 2-3.7—Concrete for Pipe Lining

3.7.1. *General.* The concrete lining of the steel cylinder may be placed by the centrifugal method, by the vertically cast method or by other approved methods.

3.7.2. *Proportioning.* The proportions of cement, fine aggregate, coarse aggregate and water used in concrete for pipe cores shall be subject to the approval of the engineer. The proportions shall be determined and controlled as the work proceeds, to obtain homogeneous, dense, workable, durable concrete of specified strength in the walls of the pipe and a minimum of defects in the surface of the pipe. The proportions shall be those which will give the best overall results with the particular materials and method of placing used for the work. A minimum of 7.0 bags of cement shall be used for each cubic yard of concrete. The water-cement ratio shall be such as to assure that the concrete will meet the strength requirements.

3.7.3. *Measurement of materials.* A barrel of cement shall be considered as 4 cu.ft. or 376 lb., and a bag of cement shall be considered as 1 cu.ft. or 94 lb. Cement in standard sacks need not be weighed, but bulk cement shall be weighed. Water for mixing shall be measured by volume or by weight. Concrete aggregates for each batch shall be measured separately by weighing. The proportions of aggregates shall be computed on the saturated and surface-dry basis and the water-cement ratio shall be exclusive of water within the aggregates and absorbed by them. The equivalent unit weights for both fine and coarse aggregates shall be determined in accordance with the "Standard Method of Test for Unit Weight of Aggregate" (A.S.T.M. C29-42), using a 1-cu.ft. cylindrical container. The equipment and devices for weighing and measuring shall at all times be accurate within 1 per cent.

3.7.4. *Mixing.* The mixing shall be thoroughly done by a batch mixer of approved type, rotating at a speed of 14–20 rpm. or a peripheral speed of approximately 200 fpm. The drum shall be entirely emptied before recharging. Mixing time shall be at least three minutes. Transit mixing shall not be used except by written authorization and under specific requirement of the engineer.

3.7.5. *Standard test cylinders.* A set of at least four standard test cylinders shall be taken from each day's pour of the mixed concrete for pipe cores made by either the centrifugal method, the vertically cast method or by other approved methods. Standard test cylinders shall be made and stored in conformance with the "Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field" (A.S.T.M. Designation C31–44). The curing of the test cylinders shall be in conformity with the curing of the pipe cores.

3.7.6. *Centrifugal test cylinders.* If the centrifugal method is used for making pipe cores, additional sets of four test cylinders of approved size and type shall be made by the centrifugal process at the beginning of the work and at intervals during the manufacture of the pipe. The number shall not exceed one set for each 400 lengths of pipe. Centrifugal cylinders shall be made by attaching to the spinning mold or frame a test cylinder mold and placing the concrete within it by spinning at the same speed and for the same interval employed in the manufacture of the pipe. The concrete shall be spun in the centrifugal test molds in approximately 2-in. layers. The test cylinders shall be tested at the expense of the purchaser in an approved testing laboratory at 7, 14 and 28 days to establish and check ratios of strength of the two types of cylinders. Upon determination of this ratio, the strength of the concrete core shall be determined by application of the ratio of strengths obtained for the two types of test cylinders.

3.7.7. *Testing cylinders.* All test cylinders shall be tested by an approved testing laboratory at the expense of the purchaser, unless the manufacturer has approved testing facilities at the site of the work. In such event, tests may be made by the manufacturer in the presence of the engineer or, if permitted by the engineer, certified test reports may be submitted by the manufacturer.

3.7.8. *Strength of concrete.* Standard concrete cylinders shall attain a compressive strength of not less than 2,600 psi. in 7 days and 4,500 psi. in 28 days. Centrifugal test cylinders shall attain a compressive strength of not less than 3,500 psi. in 7 days and 6,000 psi. in 28 days. Pipe made from concrete which does not meet the strength tests will be subject to rejection.

3.7.9. *Placing concrete by centrifugal method.* The steel pipe cylinder with joint rings attached shall be held securely by spinning frames so constructed that the cylinder will be kept truly circular. The frames shall be placed horizontally in a spinning machine capable of revolving them at speeds up to at least 3,200 fpm. The method of placing concrete in the cylinder and the speed of rotation during placing shall be such that the concrete will be evenly distributed and well compacted at the specified thickness throughout the length of the pipe. After the concrete has been deposited, the rotation shall be continued at a speed and for a length of time sufficient to provide the specified strength and suffi-

cient compaction and bond to permit removal from the spinning machine without injury to the pipe core. Excess water and laitance shall be removed from the interior surface of the pipe in an approved manner so that the surface shall be solid, straight and true. If necessary to provide a smooth surface, the interior shall be honed after curing.

3.7.10. *Placing concrete by vertically cast method.* The concrete lining or core shall be cast on end on a cast-iron or steel base ring with the cylinder used for the exterior form and a rigid steel collapsible form for the interior. The interior form shall be so designed that it will have a smooth contact surface and tight joints and will be firmly and accurately held in proper position without distortion during the placing of the concrete. The forms shall be provided with top and bottom stiffening rings and shall be designed to permit removal without injury to the inside surface of the pipe. The forms shall be thoroughly cleaned and oiled before each period of use. The transporting and placing of concrete shall be carried out by approved methods which will prevent the separation of concrete materials and the displacement of the steel cylinder or form from its proper position. Approved methods of mechanical vibrating and rodding shall be used to compact the concrete in the forms and to secure satisfactory interior surfaces. Forms shall not be removed until the concrete has set sufficiently to avoid spalling or damage to the pipe during the process of form removal.

3.7.11. *Other methods of placing the lining.* If the contractor proposes to employ a method other than the centrifugal or vertically cast methods for placing the concrete lining or core within the cylinder, he shall submit for approval complete details of the methods and equipment he proposes to use.

Sec. 2–3.8—Curing of Pipe Lining

3.8.1. *General.* The lined cylinders shall be cured by steam, by water or by the use of approved curing compounds. Steam shall be used for curing unless the temperature in the curing chamber is continuously above 50°F. and unless the water or curing compound method is specifically permitted. Adequate space and facilities shall be provided for proper curing.

3.8.2. *Steam curing.* The lined cylinders shall be placed in the steam curing chamber, and, as soon as the chamber is filled and the concrete has hardened sufficiently, the cylinders shall be kept in contact with moist steam at a temperature of at least 110°F. and not more than 150°F. for a period of at least 36 hours. Curing by steam shall be continuous, except during a period sufficient to remove the inner form or supporting rings. The form shall not be removed until at least twelve hours after the beginning of curing.

3.8.3. *Water curing.* The lined cylinders shall be kept moist by water spraying for a period of at least 36 hours. Following this minimum period, they may be "tipped" from their bases and removed to the storage yard, where they shall be kept continuously moist by intermittent spraying for a period of at least three days.

3.8.4. *Curing compounds.* An approved type of curing compound may be used for curing the cylinder linings, if specifically permitted. The compound shall be applied as soon as the forms are removed (for vertically cast cores) and as soon as the concrete is sufficiently hard (for centrifugally cast

cores), and at such time as to retain sufficient moisture for adequate curing.

Sec. 2–3.9—Pipe Coating

3.9.1. *General.* After the lined cylinder has been wrapped with high tensile wire, an exterior mortar or concrete coating shall be applied.

3.9.2. *Mortar coating.* Mortar for coating shall consist of 1 part cement to not more than 3 parts of fine aggregate. Cement and fine aggregate shall conform to Sec. 2–2.1 and 2–2.2 herein. The mortar shall be thoroughly mixed, and, after mixing is completed, it shall be deposited under impact or vibration by an approved method so that a dense, durable coating of a minimum thickness of ¾ in. will be obtained.

3.9.3. *Concrete coating.* Concrete for coating shall be of an approved mix. It shall consist of 1 part cement to not more than 4 parts of aggregates. The fine and coarse aggregates and cement shall meet the requirements of Sec. 2–2.1, 2–2.2 and 2–2.3 of this document, except that the grading of coarse aggregate shall be such that it will all pass a ½-in. laboratory sieve. The concrete shall be placed and compacted by approved methods and equipment so that a dense, durable coating of a minimum thickness of 1 in. will be obtained.

3.9.4. *Strength.* The coating shall develop a 7-day compressive strength of at least 2,600 psi. and a 28-day compressive strength of at least 4,500 psi. when sampled and tested by the standard method specified in Sec. 2–3.7.7 herein.

Sec. 2–3.10—Curing of Coating

3.10.1. *General.* The coating outside the cylinder shall be cured by steam, by water or by the use of approved curing compounds. Adequate space and facilities shall be provided for proper curing.

3.10.2. *Steam curing.* The coated pipe shall be placed in the curing chamber as soon as practicable after placing the coating and shall be steam-cured as specified under Sec. 2–3.8.2. for a period of at least twelve hours. The pipe shall be handled in such a manner as to avoid injury to the coating during transportation to and from the curing chamber.

3.10.3. *Water curing.* As soon as the coating has set sufficiently, it shall be kept moist by continuous water spraying or by intermittent spraying and burlap and canvas covering for a period of at least four days.

3.10.4. *Curing compounds.* If specifically permitted, approved curing compounds may be used to cure the coating. They shall be applied as soon as the coating is sufficiently hard to prevent damage to it and while the coating still retains sufficient moisture for adequate curing.

Section 2–4—Specials and Fittings

Sec. 2–4.1—General

The manufacturer shall furnish all fittings and special pieces required for closures, curves, bends, branches, manholes, air valves, blowoffs and connections to main-line valves and other pipes shown on the contract drawings or ordered by the purchaser. Specials shall conform to the details furnished by the purchaser, or, if required, to the details furnished by the manufacturer and approved by the purchaser. Either of two types shall be used:

Type A—specials with steel-sheet cylinder, concrete or mortar lining and

reinforced concrete or mortar exterior covering;

Type B—specials of cut and welded steel plate of approved thickness, with mortar coating on interior and exterior.

Sec. 2–4.2—Specials (Type A)

The steel sheet shall be cut, shaped and welded to form the properly shaped bend, tee, reducer or other special. The welds shall be inspected and the completed cylinder shall be tested for tightness by an approved method, if specifically required by the purchaser. A cage or cages of steel reinforcement with approved cross-sectional areas shall be formed around the cylinder and openings. Longitudinal reinforcement sufficient for the additional stresses in the pipe walls shall be provided. The interior and exterior concrete or mortar shall be placed in an approved manner.

Sec. 2–4.3—Specials (Type B)

4.3.1. The steel plate for the fabricated steel plate specials shall be cut, shaped and welded so that the finished special shall have the required shape and interior dimensions. The deflection angle between adjacent segments of a bend shall be not greater than 22½ deg. Adjacent segments shall be joined by butt welding. The minimum length of the courses shall be one-half the diameter of the pipe. Fabrication and welding shall conform to the requirements of Sec. 2–3.5 of these specifications and to such additional requirements for welding steel plate as the purchaser specifically stipulates.

4.3.2. Wire mesh reinforcing shall be applied to the interior and exterior surfaces of the fabricated special. It shall be 2 × 4-in. No. 13 gage welded wire fabric, held ⅜ in. from the surfaces of the steel plate. The members on the 2-in. spacing shall extend circumferentially around the special with ends overlapped 4 in. and tied together. Longitudinal splices shall be staggered.

4.3.3. The steel plate specials shall be lined and coated with mortar at least ¾ in. thick, deposited on the surfaces by approved means. The mortar shall contain not less than 1 part cement to 3 parts sand, of a grading approved for the method of application used, and shall develop a 7-day compressive strength of not less than 2,600 psi. and a 28-day compressive strength of not less than 4,500 psi.

4.3.4. The mortar-coated specials shall be cured by water spraying, by steam or by curing compounds as specified under Sec. 2–3.10 herein.

Sec. 2–4.4—Curves, Bends and Closures

Horizontal and vertical long-radius curves shall be formed by straight pipe in which spigot rings are placed on a bevel. The total angular deflection for beveled pipe shall not exceed 5 deg. at any joint. Slight deflections may be made with straight or beveled pipe, provided that the maximum joint opening caused by such deflections shall not exceed ¾ in. for 16–36-in. pipe and 1 in. for 42- and 48-in. pipe. Short-radius curves and closures shall be formed by fabricated specials of either of the two types specified above.

Sec. 2–4.5—Openings and Connections

Manholes and flanged, spigot or bell connections for air valves, blowoffs or connections to other pipes shall be built into the walls of the concrete pipe at locations shown on the contract drawings or ordered by the purchaser. If required, the interior and exterior surfaces of structural steel connections

shall be lined and coated with reinforced mortar as specified in Sec. 2–4.3 of these specifications. Wall openings shall be formed by welding a saddle plate of approved thickness completely around the steel cylinder. The high-tensile wire shall be securely fastened upon each end of the saddle plate. The casting shall be welded to the saddle plate after the hole is cut through the plate, cylinder and inside concrete. Mortar or concrete coating reinforced with welded steel fabric shall be placed on the exterior of the saddle plate and around the neck of the fitting in an approved manner.

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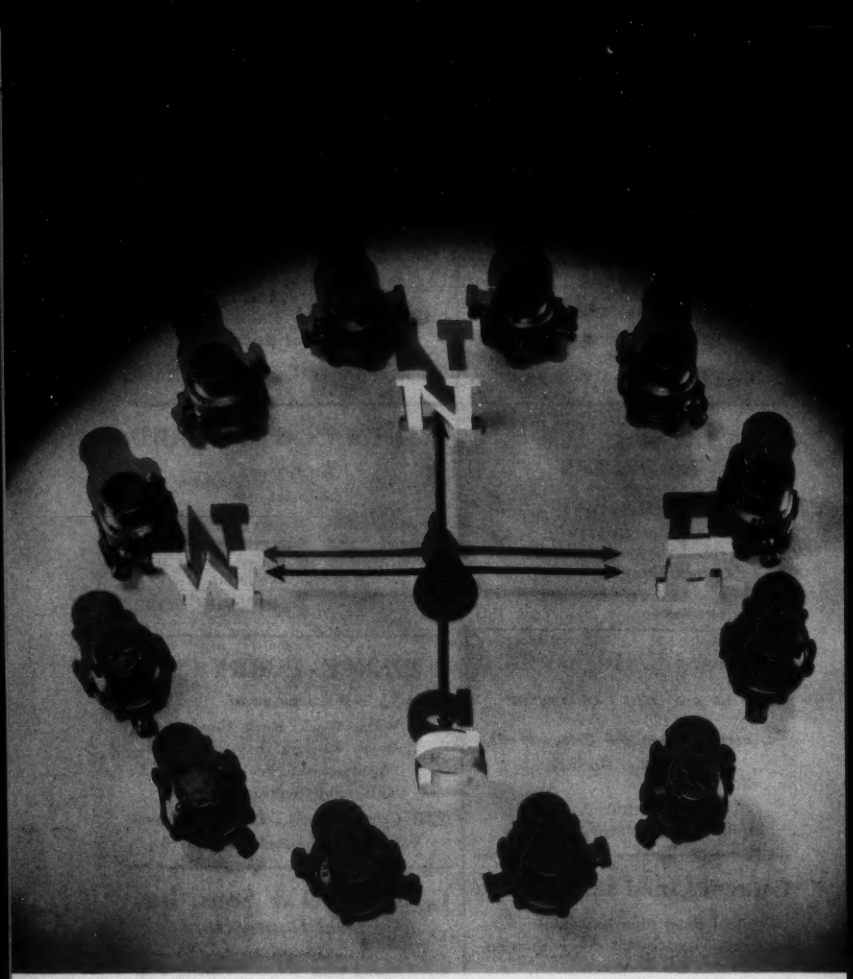

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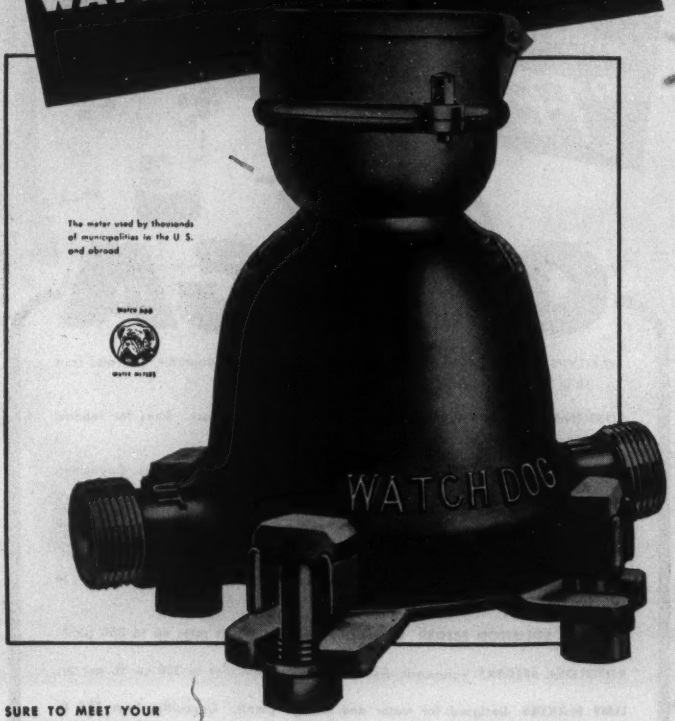

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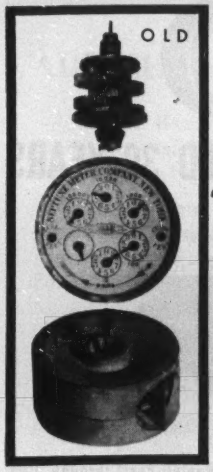

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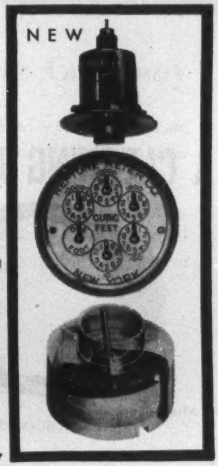

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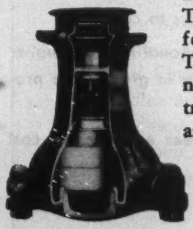

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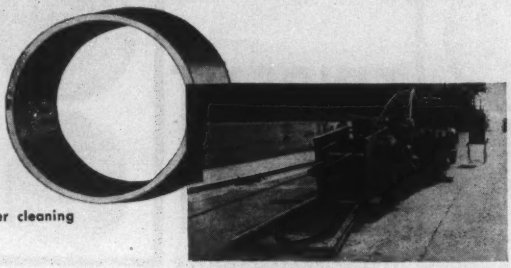

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In 1945 a five year program to clean and recondition the entire water main system of Washington was begun and National in conjunction with the Centriline Corp. was successively awarded the cleaning contracts for 1945, 1946, 1947, 1948, and 1949, — in short, all the cleaning jobs to date!

It was because of that unusual record that Toledo's progressive water works department *has again selected National* to clean its entire water main system—a program that will take over five years to complete.

Tests made on those lines already cleaned by National indicate higher pressure and increased carrying capacities, resulting in greater fire protection for Toledo's outlying districts.

There's no obligation to have a National engineer estimate the cost of cleaning your lines. Why not write *today!*

30

NATIONAL WATER MAIN CLEANING CO., 50 Church St., N.Y. 7, N.Y.

ATLANTA, 333 Candler Building & P. O. Box 9 — Station E • BOSTON, 115 Peterboro Street • CHICAGO, Room 1336 So. Michigan Ave. • KANSAS CITY, 406 Merchandise Mart, 2201 Grand Ave. • LOS ANGELES, 448 South Hill Street • LITTLE FALLS, N. J., P. O. Box 91 • OMAHA, 3812 Castellar Street • RICHMOND, 210 East Franklin Street • SPRINGFIELD, Mo., 1301 Prospect Ave. • SALT LAKE CITY, 149-151 W. Second So. Street • SAN FRANCISCO, 681 Market Street • SIGNAL MT., TENN., 204 Slayton Street • FLANDREAU, S. D., 315 No. Crescent St. • MONTREAL, 2028 Union Ave. • VANCOUVER, B. C., 505 West 1st Avenue • WACO, P. O. Box 887 • WINNIPEG, 576 Wall Street • HAVANA • SAN JUAN, PUERTO RICO • BOGOTA • CARACAS • MEXICO CITY

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Within the Boston Edison Company is a staff of experienced men thoroughly qualified to give you advice on any branch of our electric service.

Whether you are interested in better lighting — air conditioning — industrial heating — commercial cooking or any other electrical improvement the assistance of these men is available to Boston Edison customers without cost or obligation.

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Stock Up for Spring Work

4" to 12" C.I. Short Pattern Fittings
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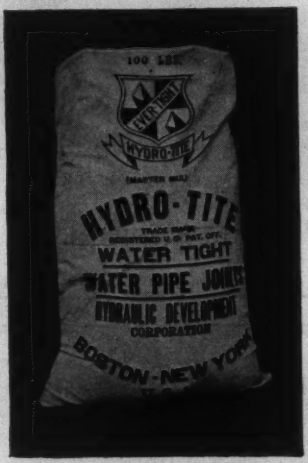
HYDRO-TITE



TESTED FOR OVER 30 YEARS

For more than thirty years water works superintendents have been using Hydro-tite for joining bell and spigot pipe. They have found that this self-caulking, self-sealing compound costs less to buy, requires less labor, makes tighter joints and withstands the effects of time, strain and vibration. Send for data book and sample.

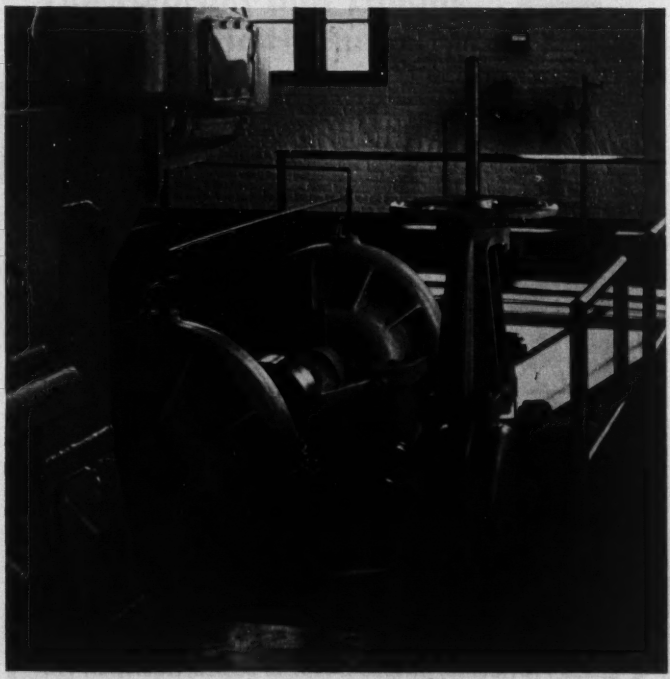
Always use Fibrex, the bacteria-free packing for pipe joints. Send for sample.

HYDRAULIC DEVELOPMENT CORPORATION

Main Sales Office: 50 Church St., New York, N. Y.

Works: West Medford Station, Boston, Mass.

WATER FOR MANCHESTER



12 MGD Fairbanks-Morse Diesel Pumping Unit at Manchester, New Hampshire's High Pressure Pumping Station.

The City of Manchester now enjoys real pumping efficiency at its modernized high pressure station. Two Fairbanks-Morse 16 inch Centrifugal Pumps, operating in series, deliver twelve million gallons a day into the Manchester water supply lines.

Pumps are direct connected to a Fairbanks-Morse, 960 Horsepower Opposed Piston Diesel.

A trained Fairbanks-Morse Engineer is on call to help solve YOUR pumping problems.

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FOR FLOW MEASUREMENT AND CONTROL OF LIQUIDS, AIR, DRY MATERIALS

BE WISE . . .

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STANDARDIZE!

Builders offers you a complete line of FLOW metering and controlling equipment — tested and approved by actual use throughout the waterworks field. For accuracy and dependability, it pays to standardize on BUILDERS — the modern equipment backed by over half a century of continuous research, development, and improvement. For Bulletins and engineering recommendations, address Builders-Providence, Inc. (Division of Builders Iron Foundry), Providence 1, R. I.

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THE VENTURI METER • TYPE M SUPER-ACCURATE FLOW METERS
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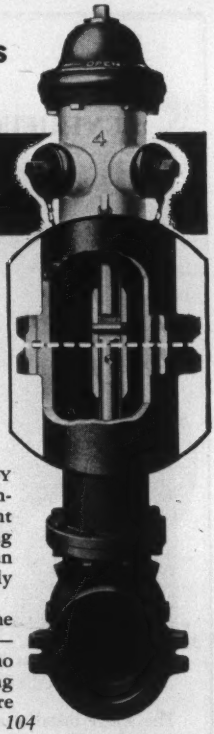
BUILDERS PROVIDENCE
Instruments

The Hydrant that Laughs at Traffic Hazards

KENNEDY SAFETOP



As tough as they come . . .

but when it breaks, it's as clean as a whistle . . . at ground level.

yet, it's back in service in twenty minutes.

The safety breakable section of a KENNEDY Safetop Fire Hydrant will take all the punishment that a standard one-piece hydrant will. But when a couple of tons of flying steel hits it at high speed—and it's more than any hydrant can take—it breaks cleanly and evenly at ground level.

Within twenty minutes of arrival at the scene one man can have it back in service—no excavation—no water—no hoists—no costly replacements. A new breaking ring and a new stem coupling are all that are usually required. *Write for Bulletin No. 104*

Where there is no traffic hazard install a KENNEDY Standard Hydrant with 1-piece standpipe and stem

- **The same minimum friction, maximum water supply design.**
- **The same positive drainage to protect against freezing.**
- **The same leak proof construction and ease of inspection . . . and all parts interchangeable with the SAFETOP except the standpipe and stem.** *Write for Bulletin No. 38*

THE KENNEDY VALVE MFG. CO.
1033 EAST WATER ST.
ELMIRA, NEW YORK

VALVES • PIPE FITTINGS • FIRE HYDRANTS

OFFICE-WAREHOUSES IN NEW YORK, CHICAGO, SAN FRANCISCO • SALES REPRESENTATIVES IN PRINCIPAL CITIES

DE LAVAL

CENTRIFUGAL WATER WORKS PUMPS

Water Works Pumping Station, Town of Topsfield, Mass.

The above installation was completed in late 1949 and represents a typical modern small Water Works installation. The pumps are rated at 250 GPM each against 247 ft. T.D.H., and the unit in the foreground is provided with emergency gasoline power. Our contract covered complete installation, including piping, wiring, painting, etc., and the entire installation was made in accordance with specifications prepared by Clinton Foster Goodwin, Consulting Engineer, Haverhill, Mass.

TURBINE EQUIPMENT COMPANY OF NEW ENGLAND

80 Federal Street **Phone LIberty 2-5993** **Boston 10, Mass.**

New England Representatives for

DE LAVAL STEAM TURBINE COMPANY

TRENTON, NEW JERSEY

Ingot or Wool?

Whether the caulking job calls for ingots for cast lead joints or lead wool for cold caulking, the primary requirement in either case is lead of high purity.

Don't take chances with inferior caulking lead which may have been manufactured from scrap material containing a large percentage of impurities.

When present in a caulked joint, impurities on the surface will corrode and cause weak spots. The stresses due to normal pipe movement concentrate at these areas and failure results.

Our lead, both in ingot and wool form, is made from selected metals and carries the Lead Industries Association Seal of Approval as a guarantee of its quality.

OTHER PRODUCTS—

LEAD PIPE
SOLDER
WHITE LEAD
RED LEAD

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M-SCOPE Pipe Finder

LIGHTWEIGHT MODEL

Catalog No. 25F

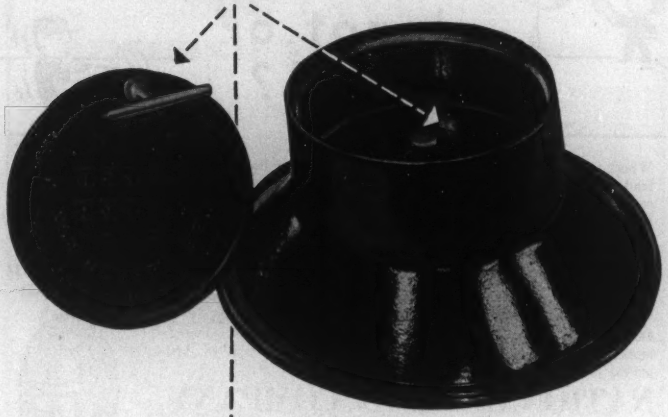
On Request

JOSEPH G. POLLARD CO., Inc.

Pipe Line Equipment

New Hyde Park New York

WABASH DOUBLE-LID COVERS



for MAXIMUM PROTECTION from frost

WRITE FOR CATALOG

The new No. 50 Ford Catalog contains full information. FREE. Send today.

The Wabash Cover was designed to provide the utmost in frost protection for pit water meters. Two lids, with a 4" dead air space between, add extra insulation. Notice also, the extra depth and the sloping skirt that help hold heat loss to a minimum.

Top lid is inset and locked with the patented Ford Lifter Worm Lock. There is no finer meter setting protection.

FOR BETTER WATER SERVICES **FORD**

Manufactured by THE FORD METER BOX COMPANY, INC.

Wabash, Indiana

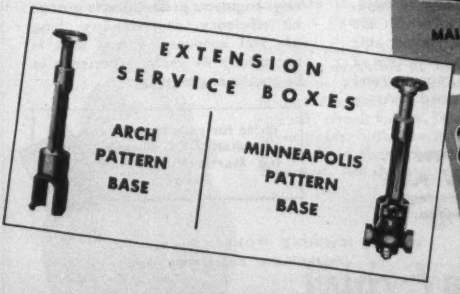
HAYS

WATER SERVICE PRODUCTS

for efficient maintenance

OVER 80 years of manufacturing experience . . . designed for easy installation . . . long years of trouble-free service . . . interchangeable with those of other manufacturers . . . corporation stops can be installed with any standard tapping machine.

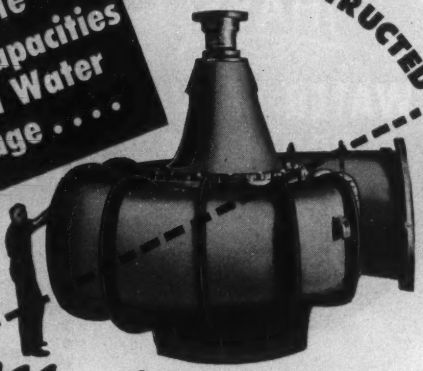
All Hays fittings made of single, uniform, high quality water service bronze, 85-5-5-5 mix . . . hydrostatically tested at 200 pounds or more . . . plugs individually ground in for perfect fit . . . specially lubricated for permanent easy turning.



HAYS MANUFACTURING COMPANY
12 TH & LIBERTY STREETS, ERIE, PENNA., U. S. A.

To handle LARGE Capacities of Storm Water or Sewage . . . .

With UNOBSTRUCTED FLOW



SPECIFY *Morris* MIXED FLOW PUMPS

The most practical type of pump, in the larger sizes, for abrasion resistance and ability to handle large stringy solids without clogging.

● In the Morris Mixed Flow sewage pump there are no guide vanes in the suction, nor stationary diffusion vanes on the upstream side of the impeller, to catch longer fibrous material. High efficiencies extend over a great range of capacity. Enclosed impellers which are most generally used are better able to withstand the abrasive action of grit and dirt. Initial capacity and efficiency are maintained over a longer period of time.

Special Feature...

Morris Mixed Flow Pumps have no internal bearings in contact with the sewage.

No other pump is so successful in maintaining freedom from clogging. In both vertical type (illustrated) and horizontal type, Morris Mixed Flow pumps have capacities ranging up to 150,000 G.P.M. In city after city, engineers prefer Morris pumps for efficiency, dependability, long life and economy. Every unit is backed by 84 years' experience in hydraulic engineering.

Write for your free copy of bulletin 178, describing Morris Mixed Flow Pumps

MORRIS MACHINE WORKS, Baldwinsville, N. Y.
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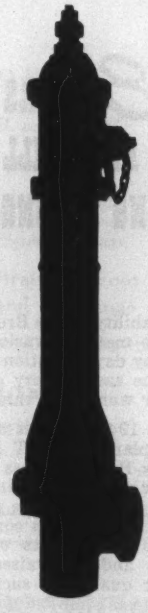
MORRIS CENTRIFUGAL PUMPS

EDDY

Valves and Hydrants

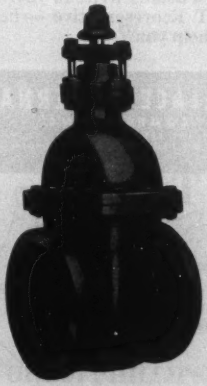


Distinctive Features of the EDDY Valves

ONLY three parts are moved by the Stem—the ball and the two gates. Each gate is hung from one of the trunnions on the ball. A convex surface at the base of each trunnion fits a concave surface on the back of the gate. This allows the gates to adjust themselves properly to their seats. . . . The gates, being free to revolve on the trunnions, do not always seat in the same position. Gates are center bearing and adjustable. They are forced to their seats with equal pressure at all points. There are two hooks on the ball on sizes 4-inch and larger, which loosely engage with the gates.

Distinctive Features of Our New Swivel Top Hydrants

THIS new hydrant has all the advantages of the popular EDDY fire hydrant, plus several additional features. . . . Nozzles are in a short flanged section of the standpipe, which may be unbolted and turned to different positions. . . . Should the standpipe be broken, only the casting below the swivel head need be replaced. . . . To raise the hydrant to conform to a new grading, simply insert a flanged extension piece below the swivelhead. No digging. To add a steamer nozzle at any time, it is only necessary to replace the swivel head with one having a steamer nozzle.



Besides valves and hydrants to meet the most exacting demands of waterworks service, the complete EDDY Line includes: valves for sewage disposal works; valves for steam, gas and oil; check valves, foot valves, plug valves, shear gates, indicator posts, etc. EDDY valves are made in three classes: Iron Body Bronze Mounted, All Bronze, and All Iron Valves.

Eddy Valve Co.

WATERFORD NEW YORK

8 YEARS AND STILL GOING STRONG

The ability of the Break-Point Process to meet the various demands of day by day operation is aptly shown by the case history of a municipal water works in Pennsylvania.

Since 1941, when it was installed at this plant by W&T Engineers, the Break-Point Process has played a major role in producing a pure, sparkling water for the system's many consumers. It has completely eliminated complaints on tastes and odors and has raised the finished water quality to such a high level that tests show *no* gas formers and *no* bacteria on the plates. In addition, a staff report continues, the Break-Point Process was of particular value in keeping the water acceptable to consumers during an emergency plant overload of 120%.

These accomplishments and such additional benefits as longer filter runs and iron and manganese removal are typical of what you receive with the Break-Point Process backed by W&T Equipment.

In the complete line of W&T chlorinating equipment, proved by over 35 years' experience all over the world, there is a chlorinator that will give *your* plant these benefits, too.

For more details write to your nearest W&T Representative — he'll be glad to help you.

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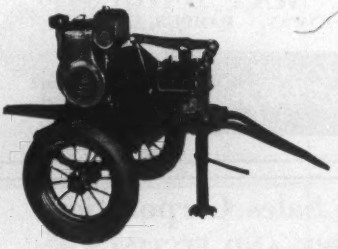
EDSON

PUMPS and ACCESSORIES



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Edson Diaphragms

Depco Centrifugals

Edson Special Hose

Edson Strainers, Foot Valves and Couplings

Pipe Locators - Thawers

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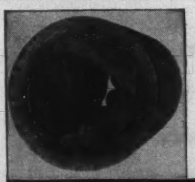
Bell and Spigot Pipe

Special Castings *Short Body B. & S. Specials*

Warren (WF) *Spun Centrifugally Cast Iron Pipe*

WORKS: PHILLIPSBURG, N. J. and EVERETT, MASS.

Large Stock Enables Us to Make Prompt Shipments

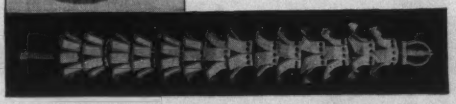


Get Full Service From Old Mains

The most practical way to meet today's overload demand is to clean clogged water mains. FLEXIBLE Underground Pipe Cleaning Co., specializes in such jobs— any size—2″ to 72″.

RAY BAHR

41 GREENWAY, HAMDEN, CONNECTICUT



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CAST IRON PIPE AND FITTINGS

FOR

Water, Steam, Gas and Culverts

Special Flanged and Bell and Spigot Castings

Lyncast Iron Chemical Castings

Office: 6 Beacon Street, Boston **Warehouse and Yard: East Cambridge, Mass.**

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Distributors of Water Works Supplies and Materials for Mains and Services

Revere Copper Tubing, Type K

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Cast Iron Fittings—AWWA or Short Pattern

Mineralead Jointing Compounds

Construction Tools: Shovels, Cold Cutters, Lanterns, Picks, Sledges.

Jointing Materials: Twisted or Braided Jute, Runners, Pots, Ladles, Hydro Rings, Pig Lead and Lead Wool.

Furnaces: Complete Hauck Line.

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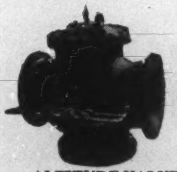
1879—ROSS— 1879

AUTOMATIC VALVES



Controls elevation of water in tanks, basins and reservoirs

ALTITUDE VALVE

1. Single Acting
2. Double Acting

Maintains desired discharge pressure regardless of change in rate of flow

REDUCING VALVE

Regulates pressures in gravity and pump systems; between reservoirs and zones of different pressures, etc.

Maintains levels in tank, reservoir or basin

1. As direct acting

2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

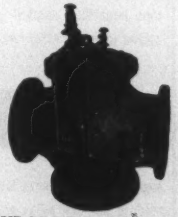
FLOAT VALVE

A self contained unit, with controls three or more automatic

COMBINATION VALVE

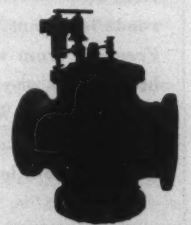
Combination automatic control both directions through the valve.

Maintains safe operating pressures for conduits, distribution and pump discharge



SURGE-RELIEF VALVE

Electric remote control—solenoid or motor can be furnished



REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

ROSS VALVE MFG. CO., INC. Box 592 TROY, N. Y.

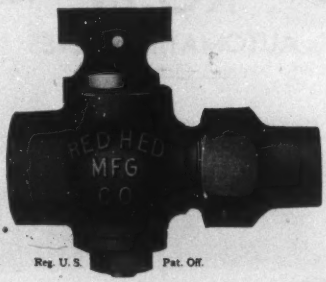


Fig. 408

RED HED Copper to Iron Stop — One Nut

RED HED CORPORATIONS FOR COPPER SERVICE TUBE

HAND GROUND—HEAVY PATTERN—SOLID PLUGS (EXCEPT WATERWAY)
MADE WITH ANY DESIRED THREAD

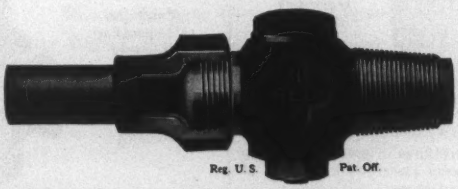


Fig. 438 Corporation and Compression Nut 438-A

Renewing or repairing brass goods under costly streets or roads is expensive and annoying.

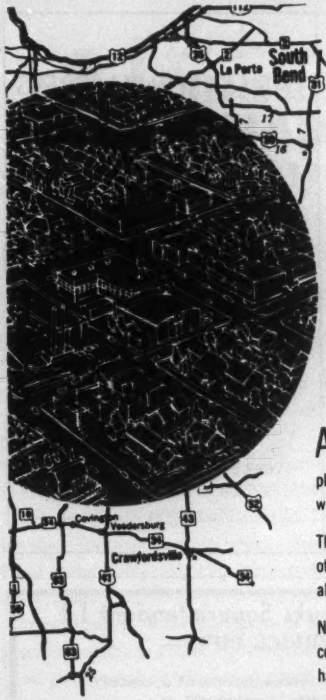
Freedom from such trouble can be avoided when RED HED brass goods are used. All RED HED Stops and Corporations are made with *hand ground plugs* lapped to the body of the Stop or Corporation, insuring ease of turning of the plug and freedom from leakage.

RED HED MFG. CO.

Makers of

High Grade Brass Goods for Water Works

368 Congress Street **Boston 10, Mass.**



the facts reveal how Ozone solved an outstanding water problem

A typical industrial city, with an especially difficult water problem, Whiting, Indiana, will soon complete its 10th year of successful taste and odor control with Ozone.

This Welsbach-Ozone system was installed after all other attempted methods failed to produce a palatable water.

Now, after a decade of actual experience with Ozone, consumers and officials alike agree that the problem has been overcome.

To consumers, the Welsbach-Ozone installation has brought a water supply free of undesirable characteristics.

For operators of the Whiting plant, the Welsbach-Ozone installation has performed with high efficiency and low cost. The Welsbach unit at Whiting has a capacity of 3 mgd with an average flow of 2 mgd. Carefully-maintained records indicate an approximate operating cost for Ozone of only $2 per 1,000,000 gallons—in a situation that has been described as the worst raw water condition in the United States!

If taste, color or odor are involved in your city's water problems, Ozone may be the effective, economical answer. Your inquiry to The Welsbach Corporation will bring you prompt information without obligation on your part.

THE WELSBACH CORPORATION

OZONE PROCESSES DIVISION
1500 Walnut Street Philadelphia 2, Pa.

Tegul-Mineralead* AND HYDE-RO RINGS

the best way to join bell and spigot pipe

Tegul-Mineralead is easy and clean to work with, economical, too—needs no skilled labor, caulking or deep bell holes. HYDE-RO RINGS, rubber ring packing, are recommended for use with Tegul-Mineralead. Please write us at 17 Walnut Street, Mertztown, Penna., and request Bulletin No. M10-1 and M10-5.

THE ATLAS MINERAL PRODUCTS COMPANY
MERTZTOWN, PENNA. HOUSTON, TEXAS

*Trade Mark Registered

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WORCESTER, MASSACHUSETTS

Attention Mr. Water Works Superintendent ! !

CEMENT LINED SERVICE PIPE:—

Resists Corrosion

Has proven practical for nearly three-quarters of a century

Immediate delivery can be made to waterworks on both wrought iron and steel, black or galvanized.

"SPECIFY EUREKA PIPE"

EUREKA PIPE COMPANY, Inc.

Manufacturers of CENTRIFUGAL CEMENT LINED PIPE and LEAD AND TIN LINED FITTINGS

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Chemical Fire and Rust Proofing Corp.

Lining and Coating of Pipe, Couplings, Joints, Tanks, Piling, Structural Steel with Bituminous Enamel or Hydraulic Cement in strict conformity with AWWA Specifications.

Ask for quotations

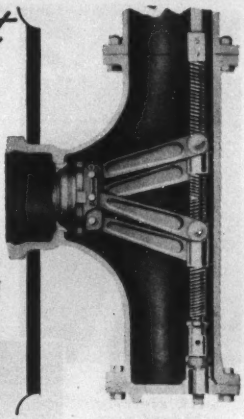
84½ Berkeley Street, Boston, Mass — LIberty 2-5185

No Sir.... that

RENSSELAER MAIN VALVE

can't open by barrel breakage

IT'S MECHANICALLY LOCKED SHUT

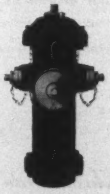


HERE'S another feature of the famous Rensselaer Hydrant—NO FLOODING if barrel is broken. The main valve is MECHANICALLY LOCKED shut by steel forgings bearing solidly against the case. Hard rubber valve seats stay tight—won't leak or scar. This Hydrant can't open unless the stem is rotated.

What's more, if the standpipe is broken off, the ground line flange makes replacement quick and easy—no pavement breaking, no digging

Yes, this Rensselaer Hydrant is a first-class investment. Valve stem won't "freeze." All working parts lift out easily, quickly. No water hammer. Drains fast without clogging. Solid bronze gives long life to vital parts. In short, SOUND DESIGN, a sound buy, proven by thousands in service making good the Rensselaer reputation. See a Rensselaer Representative for details—just call our nearest office.

THE FAMOUS RENSSELAER COREY HYDRANT



See how....

THE FLANGE AT GROUND LINE ELIMINATES DIGGING UP

7

LEADERSHIP FOR OVER 65 YEARS

RENSSELAER VALVE COMPANY

Hydrants • Gate Valves • Square Bottom Valves
Check Valves • Tapping Sleeves and Valves • Air Release Valves

TROY, NEW YORK

Division of Neptune Meter Company

Atlanta, Bala-Cynwyd, Pa., Chicago, Dallas, Denver, Haverhill, Mass., Hornell, N. Y., Kansas City, Los Angeles, Memphis, Pittsburgh, San Francisco, Seattle.

Note the radius, with strictly standard pipe and couplings.

Note the sure, simple, fast way to make tight joints for straight lines or radius.

STRAIGHT LENGTHS MAKE A RADIUS

Easy does it with K&M "Century" ASBESTOS-CEMENT PIPE

5-DEGREE deflection at each pipe joint is perfectly safe and simple in laying K&M "Century" Asbestos-Cement Pipe with "Century" Simplex Couplings (made of identical material). Offsets may go to 13 inches per standard 13-foot pipe length. With shorter straight lengths even the sharpest practical radius is easy. Nothing special is needed.

Such simplicity underscores the economy of laying this K&M pipe—inexpensive to haul—light to handle—easy to cut on the site. Continued economy comes from high resistance to soil corrosion and immunity from tuberculation and electrolysis. The initial high flow capacity cannot be reduced by tuberculating waters.

Highly resistant to the stresses of traffic and earth settlement, as well as to chemical deterioration, K&M "Century" Pipe actually gains strength as it ages. It is recoverable for re-laying in its original pressure class! Here is low cost—lastingly. Write us for full data.

Nature made Asbestos...
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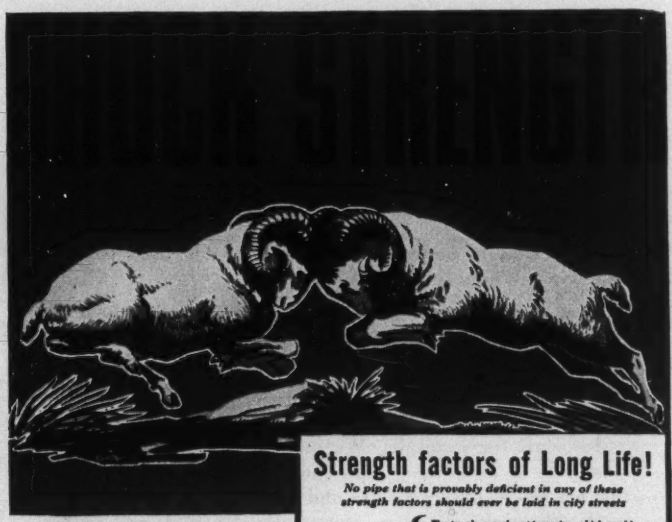

Strength factors of Long Life!

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets

SHOCK STRENGTH — The toughness of cast iron pipe which enables it to withstand impact and traffic shocks, as well as the hazards in handling, is demonstrated by the Impact Test. While under hydrostatic pressure and the heavy blows from a 50 pound hammer, standard 6-inch cast iron pipe does not crack until the hammer is dropped 8 times on the same spot from progressively increased heights of 6 inches.

CRUSHING STRENGTH — The ability of cast iron pipe to withstand external loads imposed by heavy fill and unusual traffic loads is proved by the Ring Compression Test. Standard 6-inch cast iron pipe withstands a crushing weight of more than 14,000 lbs. per foot.

BEAM STRENGTH — When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 8-inch cast iron pipe in 10-foot span sustains a load of 15,000 lbs.

BURSTING STRENGTH — In full length bursting tests standard 6-inch cast iron pipe withstands more than 2500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

Without shock strength—or, for that matter—without all of the strength factors listed opposite—no pipe laid 100 years ago in *city streets* would be in service today. But, in spite of the evolution of traffic from horse-drawn vehicles to heavy trucks and buses—and today's vast complexity of subway and underground utility services—cast iron gas and water mains, laid over a century ago, are serving in the streets of more than 30 cities in the United States and Canada. Such service records prove that cast iron pipe combines all the strength factors of long life with ample margins of safety. No pipe that is provably deficient in any of these strength factors should ever be laid in city streets. Cast Iron Pipe Research Association, Thos. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3.

CAST IRON PIPE SERVES FOR CENTURIES

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What is Quality Control? What does it do? How does it function? Whom does it benefit?

First and foremost, a quality control operation benefits the customer. It also benefits the manufacturer. It provides assurance to management that the quality level of production is equal to, and generally in excess of the standard specification.

Take us, for example. We manufacture cast iron pressure pipe in accordance with quality control specifications that are more comprehensive and exacting than the accepted technical specifications or customer's specifications under which pipe is purchased.

The first step in Quality Control is that of establishing company standards for both process methods and the physical and chemical properties of the product.

The next, backing-up step is establishing inspection procedures using statistical sampling techniques. These procedures extend from raw materials to finished product.

The final step is to have our Quality Control Dept. establish a group of facts in statistical form and analyze them for the purpose of removing quality standards from the realm of *opinion* into that of *organized facts*.

Production testing laboratories in our various plants are the tools for evaluating these quality standards.

U. S. PIPE & FOUNDRY CO.

General Offices, Burlington, N. J.

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The true value of LEADITE is best indicated by the fact that it has been used on THOUSANDS OF MILES of Water Mains,—all over this Country, as well as in many Overseas Countries.

The Pioneer self-caulking material for c. i. pipe,
Tested and used for over 40 years,
Saves at least 75%.

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